POWER

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ELY C. HUTCHINSON, *Editor*

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EDITORIALS

The Job Ahead

What a treat it has been for the editor to talk over the old N.A.S.E. and N.A.P.E. days with Fred R. Low! He has made them live anew! There is strong reason for the National Association of Power Engineers to be proud of its accomplishments of the past half century. But, the job is not finished. There is still work for the Association, and *Power* still proclaims the close relationship between intelligent operation and economic power production.

In many ways the ideals and objectives of *Power* and the N.A.P.E. are toward the same end, and it is the intention of *Power* to keep face front and step firm, in their accomplishment.

Prosperity is Made Not Born

There is great encouragement in President Hoover's program of business revival, particularly as it includes an immediate attack upon the stagnation of capital goods purchasing. The economic conference at Washington last month has brought the concentrated effort of banking and industrial committees, as well as other leading industrialists and bankers, into fighting formation for the specific purpose of breaking the industrial deadlock. Nothing could be more constructive.

But so far as the power field is concerned, it is not so much a matter of adequate bank credits as a cure for general debilitation of the aggressive fiber.

What the owners of industrial power plants need most is a potent stimulant to reinforce a weakness of business morale and civic consciousness as astounding as it is unexpected in American people.

Investigations disclose that a large number of company executives simply refuse to move at all on power modernization projects which they can readily finance from cash reserves, or by easily obtainable credit. And this despite the clearest proof by qualified engineers that savings, effected through reduced cost of power, will return thirty to eighty per cent of the capital investment annually. To make matters worse, the same people have apparently made a good job in modernizing other parts of their factories, only to forget completely that dollars saved in the cost of power are as good as any picked up elsewhere. Failure to undertake improvements where economy warrants, not only holds back recovery and is counter to self-interest, but offends the best engineering and executive traditions.

Executives should be made to realize that their inaction is not only against their own interest but is also retarding the very prosperity they keep wishing for. Then, they may rediscover some of the old time spirit and put an end to waiting for someone else to start first.

Greetings—N.A.P.E.

• TO THE N.A.P.E. on its completion of fifty years of useful existence I extend, on the part of *Power* and of myself, congratulations and earnest wishes for a long continuance of service and prosperity.

• WHEN ONE realizes the changes that the past fifty years have wrought in the qualifications required of the power plant engineer the foresight of the founders of the N.A.S.E. becomes manifest. Their idea was to merit promotion by preparation for a higher class of service and for the taking on of greater responsibilities.

• IN 1888, before I became connected with *Power,* its publishers sent me a copy and asked me to comment upon it critically. I advised that the Association was designed to be and could be made a powerful factor for the up-lift of the power plant engineer. And every time it struck the spark of inquiry and ambition in the mind of an engineer it was helping to build the kind of men that *Power* was anxious to see grow. This disposition to be helpful has marked the attitude of *Power* toward the Association through all the years of their joint

Forest Growths Curtail Water Supply

Contrary to the general belief of many, recent studies and forests and stream flow duly indicate that the maintenance of forests on watersheds greatly reduces the available water supply.

At the recent Annual Convention of the American Society of Civil Engineers, an extremely interesting

paper was presented by W. G. Hoyt, Hydraulic Engineer of the U. S. Geological Survey and H. C. Troxell, Associate Hydraulic Engineer of the U. S. Geological Survey. The paper gives the results of a number of years of observation and scientific study of areas in Colorado and California and graphically shows the average annual increase in accumulated excess of run-off as a result of deforestation. Such increases of run-off from the same areas as 15.3 per cent at Wagonwheel, Colorado and 28.7 per cent at Fish Creek, in the southern part of California, are reported as yearly averages, following approximately six years of study.

If the facts as presented in the paper are found to be generally true elsewhere, it is very likely that communities experiencing shortages in water supply, or where the water problem is critical, will find it advisable to carefully consider whether they shall maintain forestation of their watersheds for scenic and recreation purposes or possibly because of the value of the timber, or whether it will be of greater importance to deforest the drainage areas in the interest of the water supply.

The possibility of replanting drainage areas, with a type of vegetation which will not make such heavy demands upon the water supply for its growth as an ordinary forest, should also have consideration.

existence and undoubtedly will continue to manifest itself in the years to come.

● UPON THE wall of my study hangs the highly prized certificate of my membership in the N.A.S.E. It is dated September 1885, and I have been an active member in good standing ever since. Of those who were members at that time there are few survivors. This membership has meant much to me in practical knowledge acquired, in opportunities made available and in friendships that have endured and added to the good of living.

● OUR GREETINGS and well wishes to all the members of the N.A.P.E. and especially to those with whom I have foregathered upon so many pleasant occasions.

F. R. Low

Air Flow in Duct Elbows

An editorial in the July 12, 1927, number of *Power* drew attention to tests, made by Loring Wirt, published in the *General Electric Review* for the June previous, which indicate that resistance to air flow in a 90-deg. elbow can be reduced ten per cent by replacing the usual rounded elbow with one having a square outer corner and a rounded inner corner.

The published report of this work did not discuss the effect of the contour of the inner corner on flow resistance. Recent tests made at Ohio State University Engineering Experiment Station under the direction of Prof. A. I. Brown and published in the Station's News Bulletin showed that the loss in an elbow, when both inner and outer corners are square, is nearly $7\frac{1}{2}$ times the loss in the conventional rounded corner elbow having a center line radius $1\frac{1}{2}$ times the side of the square section.

These tests seem then to indicate that the shape of the inner corner of a 90-deg. elbow is more important than the outer corner and suggest the need of further research in this direction.

At the risk of being pedantic, we repeat that much of the existing data upon fluid flow will be found applicable to the design of ducts for gas flow.

Stainless Steel in Hydro Construction

Research on hydraulic cavitation while incomplete has at least extended to the point where pitting is recognized as a combination of mechanical and corrosive action.

The more homogeneous metals when used for hydraulic turbine and pump parts, have a high resistance to corrosion and corrosion-fatigue. Experience shows also that when ability to oppose these troubles is present there is also a greater resistance to cavitation.

European practice has apparently recognized these points as it now leans heavily upon stainless steel as a material for hydraulic turbine runners, pump impellers and similar services. We of the United States are familiar with this to a considerable extent but price of the metal and other considerations have held back our development in the same direction.

Kaplan turbine blades of large size are being made of stainless steel abroad. Furthermore it is almost standard practice there, to completely machine the surfaces as smoothness and accuracy of curvature greatly aid efficiency and decrease liability of cavitation. Pelton water wheel buckets are being cast of the same metal.

We shall not have acquired the proficiency of the European makers of stainless-steel hydraulic turbine and water-wheel parts until we can not only make the castings as successfully but at prices which will permit their adoption into the hydraulic field.

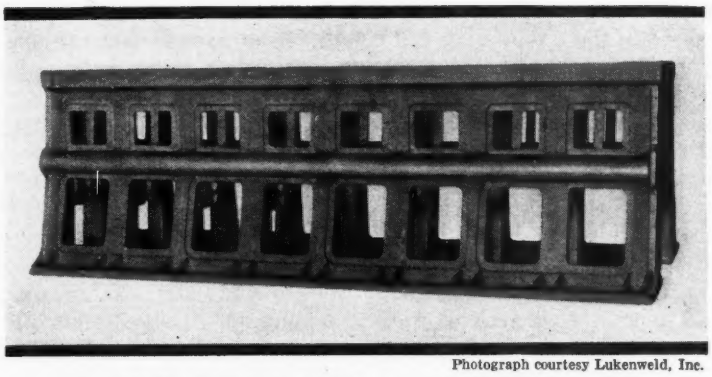
As a metal, stainless steel will be used by hydro purchasers as soon as our manufacturers can offer suitable castings at useable prices.

▼

POWER Stands for . .

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

THE METALS OF OIL-ENGINE CONSTRUCTION



Photograph courtesy Lukenweld, Inc.

A 1,765-lb. top block built for an 8-cyl., 600-hp. diesel engine by welding together rolled steel plate and sections

Born with fuel economy, the diesel engine has acquired dependability. New metals and alloys, skillfully selected and applied, are a vital factor in the rapid extension of its application. This survey[1] of diesel metals and their uses will be of interest to all power engineers.

GENERAL economic conditions are not the sole cause of the recent notable swing toward broader application of diesel power. The diesel came into existence as a means under certain conditions, of increasing the coverage of the power fuel dollar. Today its application is spreading largely because of operating dependability and low maintenance.

Addressed entirely to present and potential users, rather than to designers, this article shows how diesel manufacturers are reaching into every engineering field for metals particularly adapted to the severe service conditions under which their engines must operate.

A vast store of metallurgical and practical knowledge of materials has been gained in the design and operation of gas engines. This has been particularly true since the tremendous development of the automotive engine. Because diesel metallurgical problems are similar in many respects to those encountered with other types of prime movers, much of the knowledge gained in other fields could be applied to diesel construction after necessary allowances were made for greater forces and higher temperatures in the combustion chamber. Consequently, the materials, and particularly the metals, of oil engine construction are in a more advanced stage of development than is generally understood.

Applications of various materials to specific diesel engine uses can best be illustrated by considering the specific parts.

Diesel frames are cast of iron, steel or aluminum, or are fabricated of welded steel. Most have been of cast iron, because it is best known, easy to machine and comparatively low in cost. But harder service for the diesel has necessitated stronger and yet lighter frames, and foundry technology has made possible castings ranging from straight-silicon to high-test alloys as required for particular services. Aluminum frames are used on engines where minimum weight is desired, such as in marine service.

Another method of reducing weight materially is by welding together rolled steel plates and sections. Light weight, low cost and speedy erection without patterns are advantages of welded construction. Its present disadvantage is higher cost in complicated sections and possibly where a number of units, justifying pattern cost, are to be built. Indeed, since rolled sections of maximum unit strength are used and stress relieving is employed, bed frames may often be made lighter by welding than by casting in aluminum, with equal strength. Earlier difficulties with welding have been overcome and conservative engineers now accept it as a dependable method of joining. European builders have thus far led in application of welding to diesel construction, but a number of American manufacturers have begun its regular use.

In smaller units, the cylinders are usually cast with the top frame; in larger units they are usually made separately. This offers possibilities in the combination of welding and casting; the diesel buyer, before long, may receive an engine composed partly of welded sections and partly of cast ones, or of rolled sections welded to cast parts.

Difference in materials for cylinders rests both with application and type of engine. If the cylinder is to be without a separate liner, it will be of a cast iron, which provides the desirable maximum resistance to internal wear and a close, non-porous structure. If the cylinder is separately lined, either cast iron, welded steel or cast aluminum alloy construction may be used, the only re-

[1]Among the many sources of information, the following should be particularly mentioned: A.S.M.E. papers by R. J. Allen, H. W. Stalnaker, Julius Kuttner and Dr. Kurt Neumann, an A.S.T.M. paper by T. S. Quinn, an article in *"The Tide Water World,"* a Diesel Engine Users Association (British) paper by J. Hope Harrison and various articles on welding.

quirement being that the part shall possess sufficient strength and have water-jacket surfaces suited to resist scale formation and speed heat conduction to the cooling fluid. If of aluminum, the water jacket must be properly protected against corrosion from impure cooling water.

Cylinder wear is an important consideration in economical diesel operation. Liners were evolved for reasons of economy. In addition to the design considerations which control lubrication, ring pressure and other elements, if the liner is slow to conduct heat away from the cylinder it undergoes considerable wear by oxidation. This necessitates that it be as thin as possible.

Liners are either of the dry type (exterior surfaces protected by inclosing cylinder wall) or of the wet type (exterior surfaces exposed directly to cooling fluid). Dry liners are confined principally to small sizes because of the thicker section of the two walls and the difficulty of providing the close fit necessary for good heat conductivity at all temperatures.

Most cylinder liners are of cast iron, though some are now being made of steel and hardened Nitraloy. Cast-iron liners are dense in structure, low in silicon to resist "growth" and often include nickel and chromium to better their characteristics. Greater denseness and uniformity have recently been achieved by casting liners centrifugally, which is a process of throwing the molten metal by centrifugal force against the walls of the mold. This results in a more compact or "packed" structure.

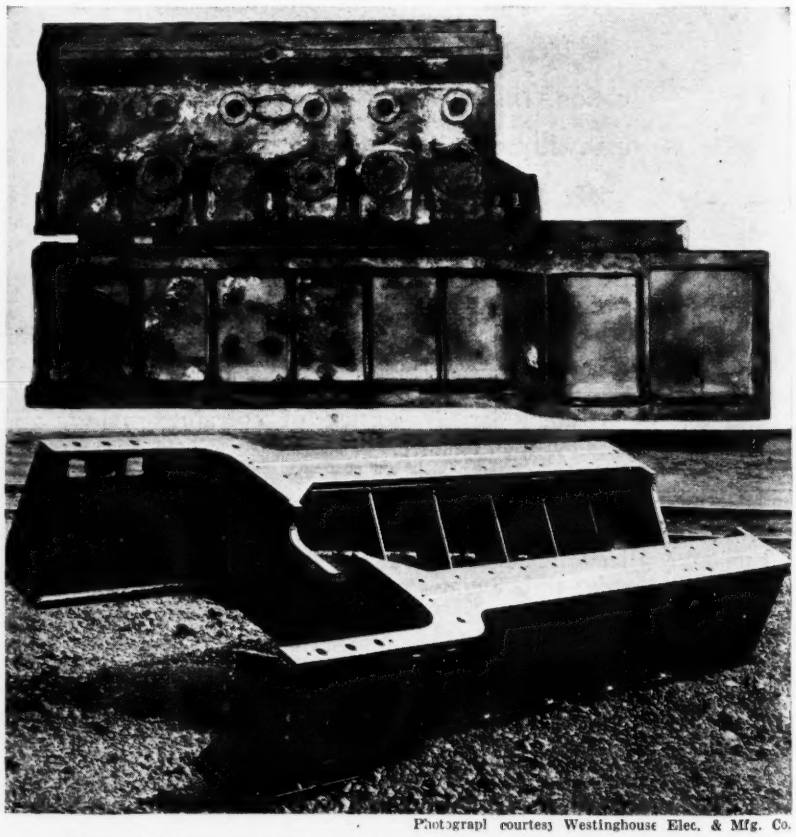
Another method of increasing density is by using a steel capable of being heat treated. Nickel and chromium added to cast iron will result in very hard liners. High-carbon steels have been used successfully where properly lubricated. These latter permit thin sections and consequent excellent cooling. Ni-Resist cast iron is used for liners in aluminum cylinders because its coefficient of expansion is about the same as that of aluminum, it is resistant to attack from heat and normal gases and takes on a "glaze" in service which protects it from wear. Nitraloy is used on smaller engines with good results.

Cylinder heads are usually cast iron, although steel is sometimes used on larger units and aluminum on smaller. The principal requirement is that the head be sufficiently strong to resist combustion pressures and of a material that will not be corroded by the air and gases of operation. Head sections of single-acting engines are usually complicated, because of the manifold passages and water cooling chambers. Consequently they are usually cast. Cast iron heads generally provide their own valve seats. Aluminum heads require insertion of aluminum-bronze, Ni-Resist or other special seats.

Pistons offer a difficult assignment for any material. They must be light in weight, high in strength, have good bearing characteristics and an expansion rate comparable to that of the liner, good heat conductivity, and resistance to attack by air and gases. No single material can meet all these requirements, hence the one selected is a compromise. Cast iron is usually used because its coefficient of expansion is the same as that of a cast iron liner. Its bearing characteristics are good and it is comparatively inexpensive. It has been found that straight-silicon irons oxidize readily in contact with hot oxidizing gases, and if there is a tendency for a local hot spot in the piston center they may fail rapidly from growth and fatigue. Nickel or nickel-chromium iron delays this type of failure.

Aluminum is being used extensively for pistons in smaller high-speed units and may eventually replace iron on larger sizes where water cooling would otherwise be necessary. Aluminum has a rather high coefficient of expansion. In smaller engines, builders control this by using inserted Invar rings and by designing to avoid the tendency to slap when cold. Expansion is sometimes taken care of by using a split skirt. While not so likely to seize as iron, aluminum must be well lubricated.

Piston rods in a double-acting diesel must be kept relatively small in order to interfere as little as possible with the capacity of the lower combustion chamber. This means that working stresses must be correspondingly high. Rods also may act as carriers for the piston cooling medium. If water is used for cooling, the matter of corrosion must be considered. Because of high working stresses and wear from packing, the natural tendency is



Photograph courtesy Westinghouse Elec. & Mfg. Co.

Above—Castings for a 350-hp. high-speed railway diesel engine. Walls had to be very thin, $\frac{1}{16}$ in., in order to save weight. The intricate upper half is cheapest cast, the lower half is simple and has been redesigned for welding as shown below

to make the rods of alloy steel, suitably heat-treated to develop strength. However, these rods do not seem to stand up as well as those of softer steels because they apparently lack the inherent toughness which is essential in resisting progressive failure. Either straight carbon or some soft alloy of the nickel-manganese type seems to work best.

Piston rings are usually straight-silicon cast iron regardless of the type of liner used. Excellent results have been obtained with nickel iron. Steel of approximately spring temper may be used in smaller sizes.

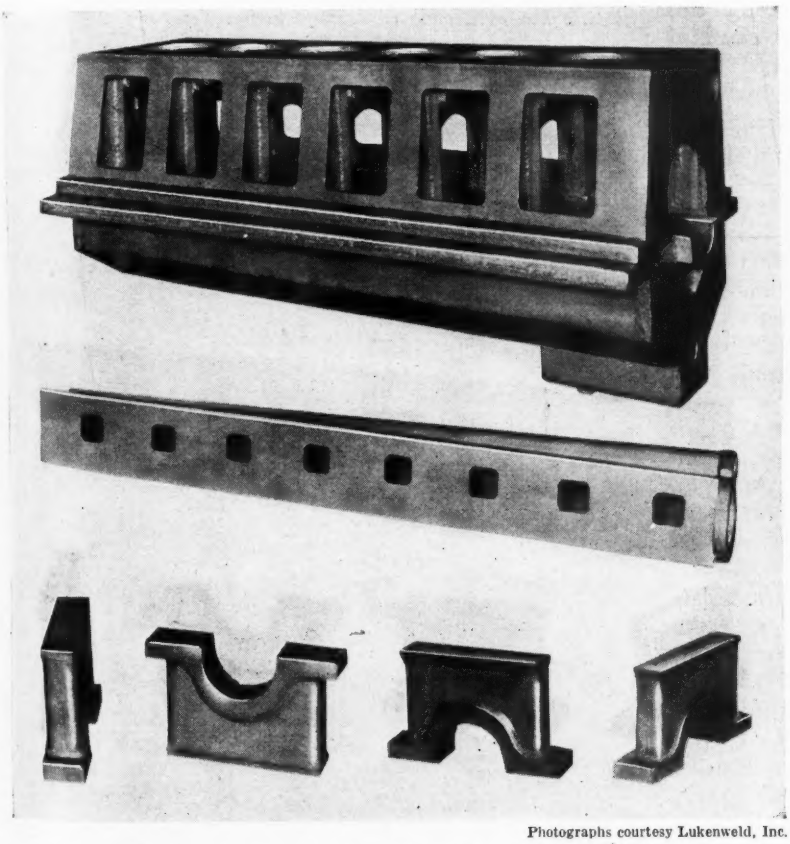
Chief requirements of a piston pin are that it be light, have sufficient strength to carry the load and proper hardness to resist wear. With adequate lubrication and suitable fit, a piston pin should resist wear indefinitely. Pins may be made of hardened tool steel, although they are usually carburized and hardened steel. Nitrided and chromium-plated pins have also been used with considerable success. Bearing bronzes of the composition type are most generally used for bushings.

Crankshafts are usually single-piece forgings which have the desirable characteristics of grain flow following the contour of the section and being continuous throughout its length. In order to obtain the necessary rigidity in the crankshaft, the section is large, hence working stresses are low, and consequently the question of strength is not serious. Most crankshafts are of straight carbon steel, although on some higher speed units a harder material may be desirable. In such cases the bearings may be hardened by case carburizing or nitriding.

Most connecting rods are of carbon steel, suitably treated, although on some smaller, high-speed units, alloy steels may be required. Aluminum may be used, but often the expense is not warranted.

Bearing conditions in a small, high-speed diesel may be quite severe, but in the usual unit they are normal. As a rule, crankshaft bearings, both main and connecting rod, are of a thin layer of white metal backed with a strong steel shell. Tin-base alloys, because of their greater strength, are preferred. The serious disadvantage in the use of most of the white metals is their low temperature operating range. When temperatures are too high for white metals, leaded bronzes may be used. Their operating limits, reached through a fusion of the lead, are in the neighborhood of 600 deg. F. Because of a high coefficient of expansion, these materials must either be used as a thin lining on a steel back or fitted with appreciable clearance. Seizure, if it occurs, is positive, but usually not destructive.

Leaded bronzes are used frequently on small, plain bearings and in guides where conditions of lubrication are difficult. In the presence of dirt, however, they tend to load and act as a lap. Camshafts and other accessory bearings are taken care of by any one of a number of the standard copper-tin-lead mixtures. Hardness must be adjusted to the mating steel.



Photographs courtesy Lukenweld, Inc.

Above—Bearing blocks for an 8-cyl., 600-hp. diesel. Center—320-lb. exhaust manifold for the same engine. At top—Crankcase assembly for a marine diesel, consisting of two sections, upper and lower. The welded assembly weighs about 250 lb. less than similar assemblies previously cast in aluminum

Exhaust valves, perhaps the hottest spots in the engine, must be of a material which will withstand the temperatures. In large engines, cast iron does well, particularly if alloyed with chromium and nickel. In small units where conditions are more severe, better materials such as chrome-nickel-silicon steels may be necessary. Ni-Resist, stainless steel and the straight chrome-nickel steels are also used, or a heat-resisting alloy head may be welded to a carbon steel or alloy stem to reduce cost.

Inlet valves, cooled continually by incoming air, require no particular attention. Good results are obtained with cast iron on the larger units and with straight alloy steels, such as carbon - chrome - nickel, on smaller. Clearance between the valve stem and guide must be small, consequently conditions for lubrication are not good. As a result, valve stems must be made as hard as practicable. Attempts have been made to do this through chromium plating, but results have not been overly successful. Guides are, as a rule, of medium hard cast iron or bronze. Valve seats are usually cut directly in the cylinder head material.

Because of the high pressures involved, and at times the corrosive nature of the oils handled, spray nozzles and pump parts must be of a hard, corrosion-resisting material. Stainless steels, suitably heat-treated, seem to meet requirements very well.

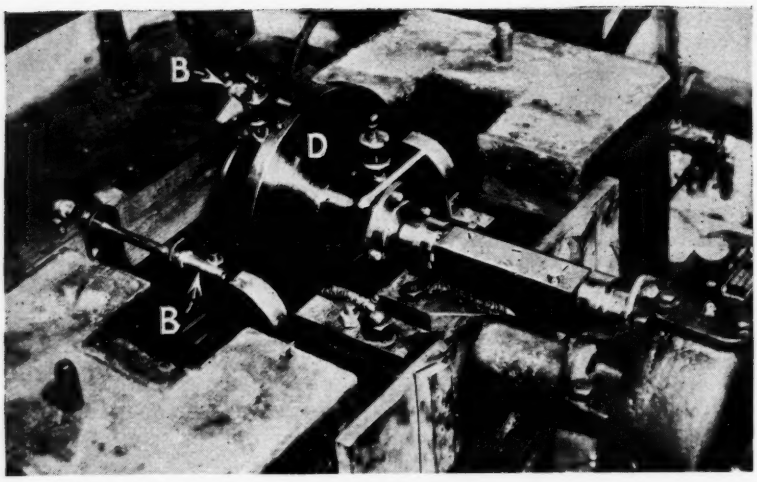


Fig. 1—Erosion-testing disk and nozzle with upper half of casing removed

Specimens of various metals whirled past a water jet at speeds up to 1,200 ft. per sec. show test results that agree closely with their actual erosion as machine parts in commercial service

ACCELERATED TESTS REVEAL EROSION-RESISTING METALS

By T. F. HENGSTENBERG

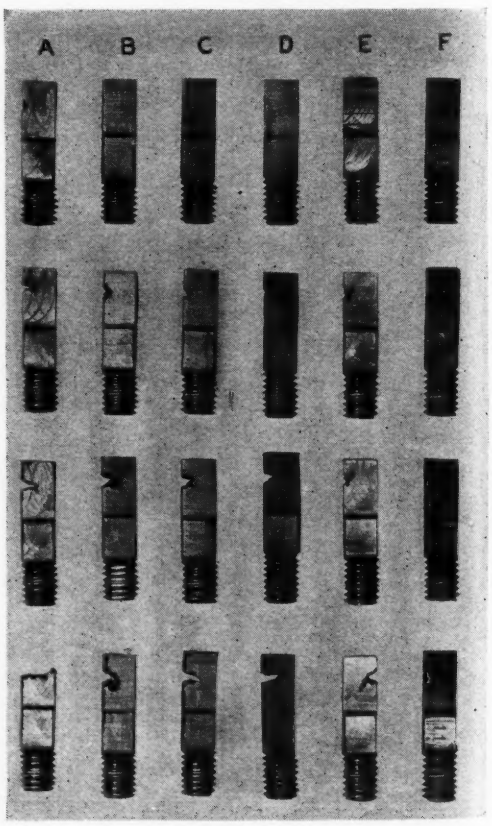
Research Laboratories
Westinghouse Electric & Manufacturing Company

NUMEROUS investigations have been made in this country and in Europe to determine the cause of erosion of metals.[1] A National Electric Light Association report in 1926 gave data on 225 hydraulic turbines, of which 90 showed more or less erosion. Steam turbine blades and aeroplane propellers are also subjected to similar action. This effect was first thought to be of a chemical nature; removing the products of corrosion was the only part attributed to erosion. No doubt the two actions, chemical and mechanical, aid each other, but in most cases one or the other will predominate.

Present opinion is that erosion is caused on aeroplane propellers and steam-turbine blading by water drops impinging on the fast moving parts and on hydraulic turbines and ship propellers by high pressures due to collapsing cavities. The theoretical pressure caused by impact of the drop of water has been calculated by several investigators to be from 50,000 to 70,000 lb. per sq.in. for a velocity of 1,000 ft. per sec.[2] Pressures in the order of 140,000 lb. per sq.in. may result from the water-hammer effect of collapsing cavities.

To withstand these high pressures harder materials must be found. Realizing the need of such research, the Westinghouse Company several years ago began an extensive study of the behavior of various alloys when subjected to a rapid erosion process. The testing apparatus consisted essentially of an impeller disk *D*, Fig. 1, into the rim of which were inserted two test pieces at diametrically opposite points. The disk, 12-in. in diameter, was driven at various speeds by an electric motor through a suitable step-up gear box. Nozzles *B* were so located

Figs. 2 and 3—Condition of erosion-test specimens after 200,000 impacts at different velocities



[1]C. A. Parson & S. S. Cook, "Investigations into the Cause of Corrosion and Erosion of Propellers," *Engineering*, April 18, 1919.

[2]Honegger, E., "Tests on Erosion Caused by Jets," Brown Boveri Review, April, 1927. Cook, S. S. "Erosion by Water-Hammer," Royal Soc. Proc., A, Vol. 119 (pp. 481-487), Gardner, F. W., The Erosion of Steam Turbine Blades," *The Engineer*, Feb. 19, 1932.

that two fine jets of water parallel to the impeller shaft crossed the path of the test pieces, approximately one inch away from the rim of the disk. Thus each specimen struck an unbroken jet of water twice per revolution. Water was used at ordinary supply-line pressure and the velocity of the jet was determined by measuring the quantity of water in a given time. The disk was mounted on ball bearings and revolved at 20,000 r.p.m. for the maximum peripheral speed of 1,200 ft. per sec.

Test specimens were machined from $\frac{3}{8}$-in. cylindrical rods to the form shown in Fig. 4. By having a rectangular section at the end exposed to erosion the impact area remained approximately constant as the erosion progressed into the specimen. The narrow edge of the rectangular section was the leading edge during a test, that is, the edge that struck the water jet. This was much more severe than most applications. The erosion produced in a few minutes of test represents several years of wear under average operating conditions.

Although the test did not exactly simulate conditions to which most machine parts are exposed, the erosion produced is similar in appearance to eroded surfaces in practice. Also, agreement of the tests with field observations is so close that we consider these results applicable to selecting materials for machine parts subjected to erosion.

The relative merits of various materials from an erosion standpoint are practically the same whether the conditions are severe or not. Tests of this type are well adapted for studying effects of velocity on rate of erosion, as the former can be accurately controlled. The velocity of water under line pressure is so small compared to the peripheral velocity that it may be neglected, the latter being from 10 to 20 times larger.

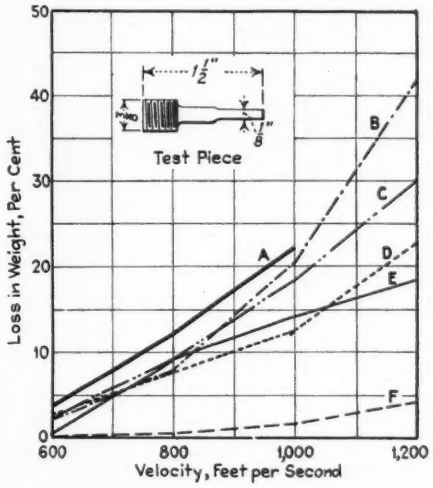


Fig. 4—Loss in weight due to erosion after 200,000 impacts shown as a function of velocity

Test Procedure Followed

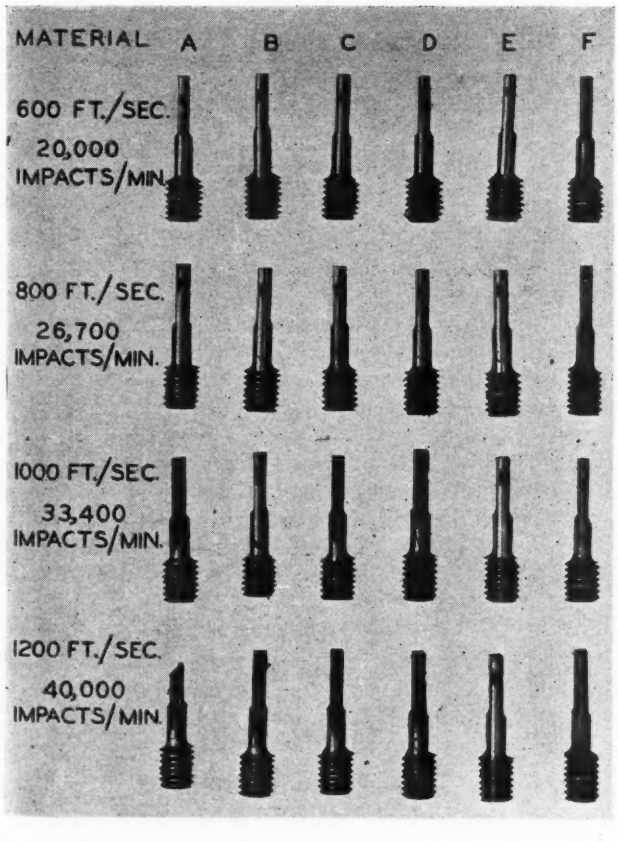
The test procedure was first to weigh the specimens accurately on a chemical balance before inserting two pieces of one material in the disk. The disk was then brought up to the desired speed, after which the water valve was opened. After a run of one or two minutes the specimens were removed and examined both for appearance and loss of weight. The specimens were then replaced in the disk and run for another short interval, after which they were again weighed. By examining the specimens at short intervals the rate of erosion and the effect of the eroded notch could be studied.

To show the effect of velocity on erosion, a number of materials were subjected to 200,000 impacts at various velocities ranging from 600 to 1,200 ft. per sec. The table gives a list of some of the materials used, with their markings as given in Figs. 2 and 3.

Mark	Material	Hardness (V.P.N.)
A	Plain carbon 0.40 c.	145
B	Cr-Ni alloy 2.20 Ni. — 12.0 Cr.	204
C	Cr-Ni alloy 0.10 Ni — 12.0 Cr.	258
D	Nickel steel.	248
E	Cr-Ni alloy 8.0 Ni — 20.0 Cr.	260
F	Case hardened — nitrided.	750

Figs. 2 and 3 show the erosion produced on the six different materials after each had received 200,000 impacts with the water jet at velocities of 600, 800, 1,000 and 1,200 ft. per sec. One exception to this is material *A* at 1,200 ft. per second. This specimen was completely cut off after 120,000 impacts. Fig. 2 is a side view of the specimens looking parallel to and in the direction of the water jet. At the higher speeds the erosion notch seems to have taken a downward path in some specimens and an upward path in others.

Specimen *E* at 1,200 ft. per sec. is of particular interest in that the notch has a marked deviation downward on the side shown, while on the opposite side the notch took an upward path. A probable explanation for this peculiar behavior is that the internal characteristics of the material, such as orientation and arrangement of the crystals or grain boundary, may be the main factors which influence the path of erosion.



Spray Cuts at High Speeds

Fig. 3 is a view looking at the leading edge of the specimens. Here an important factor in erosion testing is brought out, the effect of fine water spray on the material. The test specimens cutting through the water jets so rapidly form a spray around each nozzle which attacks the whole edge of the specimen. At the lower speeds, 600 and 800 ft. per sec., the spray had no effect on any of the materials. At 1,000 ft. per sec. however, some of the metals show the effect of spray, while at 1,200 ft. per sec. wear due to spray is excessive on materials *A*, *B*, *C* and *D*.

The spray erosion may show entirely different results

than jet erosion. This difference in erosion can be seen on materials *B*, *C* and *D* at 1,000 ft. per sec. In Fig. 2 the jet erosion is greatest in material *B*. Observing the leading edge of the same specimens, Fig. 3, spray erosion is quite pronounced in materials *C* and *D* while it has hardly affected B. On the same materials at 1,200 ft. per sec. spray erosion is greatest in *B*.

In general, the harder materials offer the greatest resistance to erosion, but there are exceptions to this rule, especially when spray erosion is considered. For example, in Fig. 2 at 1,000 ft., per sec., material *B* is softer than either *C* or *D*, yet the last two show a great deal of spray erosion, while *B* shows just a trace at the tip. Again, materials *C* and *E* are of practically the same hardness yet the erosion on them is quite different at the higher velocities.

It is obvious that erosion will increase with an increase in speed. At very low speeds all the materials are quite resistant to erosion. As the speed is increased erosion increases more rapidly with some materials than others. The curves, Fig. 4, show the loss in weight of each material after 200,000 impacts at several velocities. At 600 ft. per sec. there is little difference in the change of weight of the materials as is also true at 800 ft. per sec. with the exception of *A* and *F*. As the speed is increased above 800 ft. per sec. differences in loss of weight between the various metals increase.

At the higher speeds even the case-hardened material *F* has been eroded through the hard case after 200,000 impacts at 1,200 ft. per sec. If the test were continued beyond 200,000 impacts the soft matrix would begin to wear rapidly. Thus the hard case tends to delay the beginning of excessive erosion.

Summary of Test Results

In general, all materials are subjected to erosion, but certain metals will stand up better than others. Although the test conditions are not exactly comparable with service conditions and are much more severe than most practical requirements, the results are in close agreement with erosion observed in many cases. Most of the materials show a definite increase in erosion with an increased velocity.

Fig. 4 shows that at low speeds, although there is some erosion, most of the materials are grouped into one class. At higher speeds the less-resistant materials are separated from the more-resistant steels. Thus at low speeds there is a greater variety of materials to choose from, while great care must be taken in selecting material for higher-speed operating conditions.

▼ ▼ ▼

Protecting Stored Rubber Belts—Rubber belts should be stored in a dark, cool (not over 70 deg. F.) place, not too dry. This does not mean that belts should be stored with one end standing wet, but the storeroom air should not be too dry. Direct sunlight and warm air should be avoided wherever possible.

Further to protect the belting, the following preparation may be used to treat edges and exposed faces of rolls: 1 qt. shellac, 1 pt. alcohol, 1½ qt. household ammonia, 3 qt. water. This solution can be applied with a whitewash brush. One gallon should cover about 300 sq.ft. It can be purchased ready mixed, combined with special age-resisting chemicals. If belts are not taken down and stored, installations should be checked to be sure that tension has been removed.—(B. F. Goodrich Co. bulletin).

ELECTRIC BOILERS SOLVE HEATING PROBLEMS

By C. R. REID

Assistant General Superintendent, Shawinigan Water & Power Company

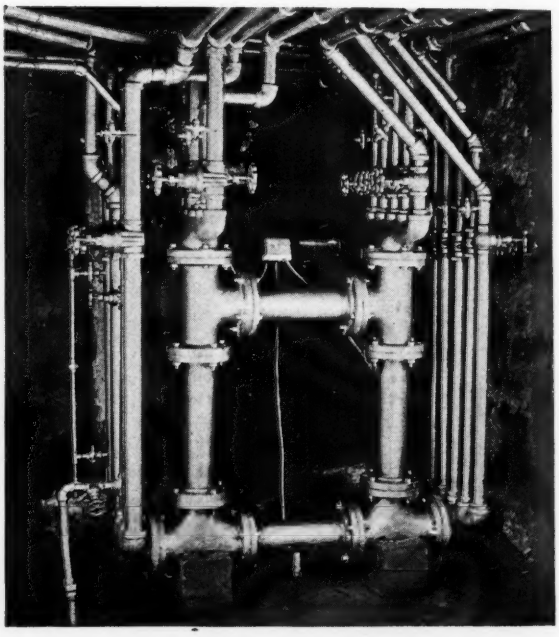


Fig. 1—Electric heater for hot-water heating system, made from pipe and fittings

WHERE electric power is bought in large blocks for industrial purposes from hydro systems, and at comparatively low rates, it may pay to use it to a limited extent for heating purposes. This will be particularly true if the amount of heat required is too small to be furnished economically from fuel or if the demand is intermittent.

The low cost of constructing apparatus to convert electric energy into heat may be a deciding factor. Devices using water as a resistor, on the principle of the Kaelin electric boiler, can usually be constructed at a low cost per kilowatt of rating. Two examples follow:

A building equipped with a coal-fired furnace and hot-water heating system was occupied during the summer months and for short periods during the winter. This building is the property of a power company and situated near a hydro-electric power house. A year ago it was discovered that the heating furnace was rusted out and would

have to be replaced. A new coal-fired furnace would have cost $300. Considering the intermittent use of the premises and the proximity of the power house it was thought advisable to install an electric water heater.

Two heating elements were constructed of 4-in. pipe as in Fig. 2. The coal-fired furnace was disconnected from the headers and removed and the electric heaters connected, as in Fig. 1. The heaters were designed for a power input of 25 kw. each at 220 volts, and were connected to a 220- to 440-volt, three-wire circuit supplied from an auxiliary bank of transformers in the power house.

It would have been possible to design the heaters for mechanical adjustment of load, but this was omitted to reduce construction cost. It was found that satisfactory control could be gained by cutting power off one heater occasionally. This

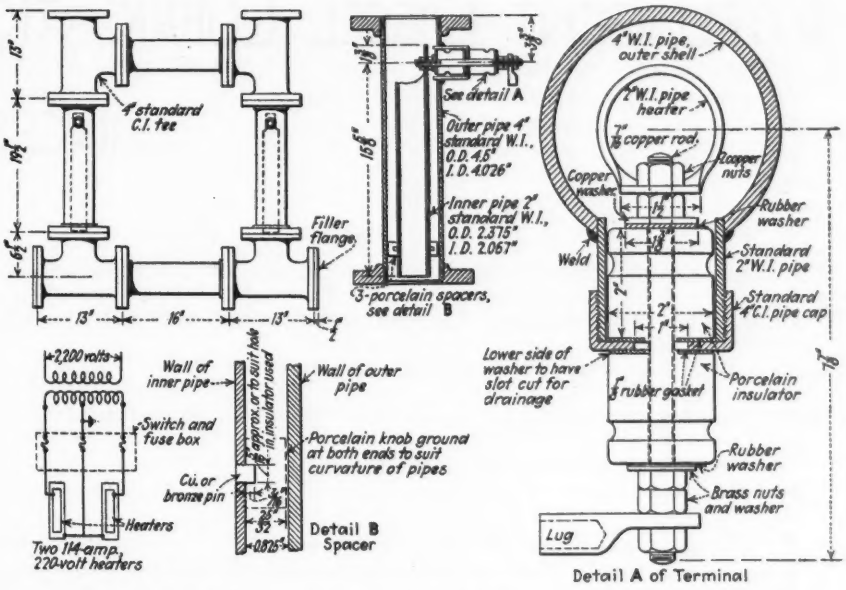


Fig. 2—Details of construction of the electric water heater, Fig. 1.

installation has been in operation a year without giving any trouble. The cost of removing the coal-fired furnace, constructing and installing the electric heaters was less than $100.

A building housing offices, rotary substation and electric locomotives of a terminal railway system was heated by low-pressure steam generated in a small vertical coal-fired boiler. The boiler was set in a pit some ten feet below the floor level of the main building. Due to lack of suitable coal-storage space and the location of the boiler room, handling of coal and ash was an awkward job. Further, the boiler tubes had reached the end of their usefulness and were in need of complete renewal.

An ample supply of 420-volt, 60-cycle power was available in the rotary substation. A Kaelin steam generator was designed and installed. This generator is rated at 100 kw., 320 volts, single phase and its steam-producing capacity is approximately 350 lb. per hr. from and at 212 deg. F.

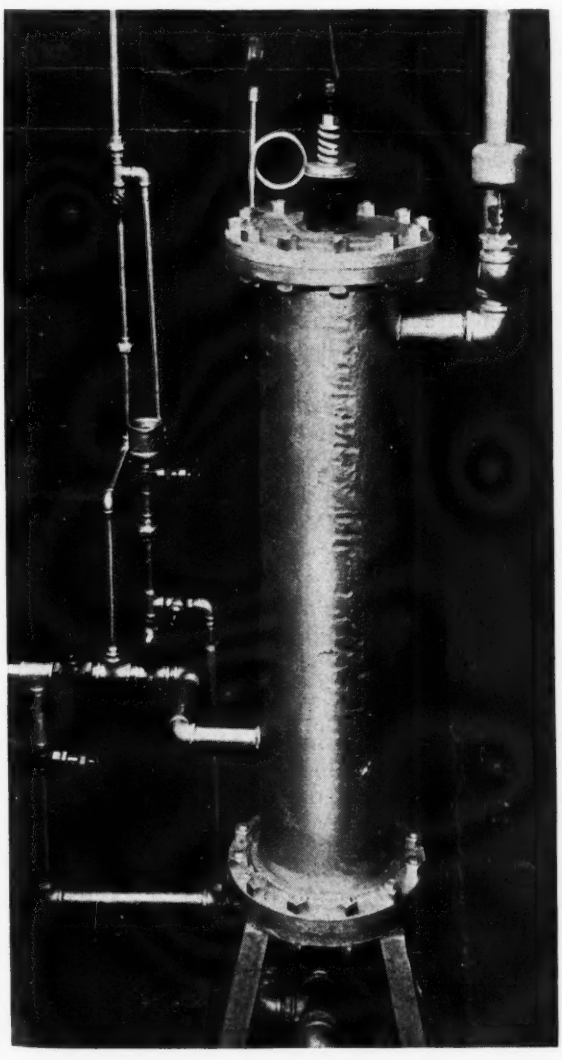
The boiler is connected to a closed heating system in which condensate is returned to the boiler by gravity. With the water at a certain level in the boiler there is a corresponding power input and consequent steam production. The water returns to the boiler at approximately the same rate as it leaves as steam; consequently operation is automatic and will continue indefinitely without supervision.

If it is desired to increase the steam output, load can be picked up by letting water into the system and raising the level in the boiler. Load can also be picked up by putting a little soda-ash solution into the water. Conversely, the load can be reduced by bleeding out water from the bottom of the boiler, primarily to reduce the soda-ash concentration and secondarily to reduce the water level in the boiler.

The shell of this boiler, Fig. 3, was fabricated from a piece of 8-in. standard black pipe with electrically welded steam and water nipples. Top and bottom blank flanges were attached to the shell by threaded connections. A safety valve is set at 12 lb. per sq.in. pressure.

The cost of this installation (including electric wiring) was $280.00, considerably less than if new material had been used throughout. The energy consumed during the first month of operation was 50,000 kw.-hr.

Fig. 3—A 100-kw. electric steam generator for heating a building. Made from a piece of 8-in. standard black pipe and fittings



INTELLIGENT DIESEL LUBRICATION INCREASES EFFICIENCY,

Lubrication is tremendously important in successful diesel operation. No more satisfactory method of assuring suitable lubrication is available than by applying practical engine-room tests. In this article the author provides a series of tests from his background of fifteen years of experience.

MOST diesel complaints and failures can be traced directly to faulty lubrication. The lubricating oils used, therefore, become tremendously important. The oils must have maximum lubricating qualities, must resist dilution and thinning at operating temperatures, should be free of foreign matter such as acids, alkalies, solids, animal and vegetable oils, should be neutral and uniform in composition, nearly odorless, capable of standing low temperatures without solidifying, and should not become gummy upon exposure to air.

There are many lubricating oils which claim these qualities, so many in fact that the operating engineer may find himself in a quandary. One sure way of determining the relative merits of oils is to test them, but here again he is at a loss. His "rule-of-thumb" methods have often led him into mistakes. He once thought thicker oils were more viscous, but found that this is not necessarily true, and that consequently, value of oils cannot be determined solely by specific gravity or viscosity tests. His color tests have likewise failed him, and he even finds that reclaimed oil may be better than new. Yet he must achieve a result satisfactory for his particular plant.

Perhaps a short discussion of the basic qualities of oil will serve to clarify the point sufficiently for an understanding of the accompanying simple tests, which any engineer can apply to find the relative merits of oils submitted for his consideration.

Lubricating oils should be mineral in character. Mineral oils are distilled from reduced petroleum crudes at temperatures above 572 deg. F., yet they burn in air at around 475 deg. F. Only pure unadulterated oils are satisfactory for diesel use, but many compounded oils are offered which are simply cheap light oils with gummy adulterants added to raise the viscosity. Herein lies the the danger in buying oils from an unreliable source. The mineral oil used in the manufacture of these cheap oils is usually very low in flash point, and is totally unfit for use in the diesel engine. Mineral oils may be classified as to their approximate flash point and specific gravity as follows:

Name	Spec. Gravity	Flash Pt., Deg.	Burning Pt., Deg.
Solar Oils	860–900	370	445
Mixed Oils	880–890		
Spindle Oil, No. 1	895–900		
Spindle Oil, No. 2	900–906	394	468
Machine Oil, No. 1	906–910	426	487
Machine Oil, No. 2	910–915	441	525
Cylinder Oil, Pale	915–920		
Cylinder Oil, Dark	920–950	*	*
Vulcan Oils	910–960		

*And up.

The general run of good lubricating oils will show a boiling point from 600 to 700 deg. F.; flash point from 325 to 500 deg. F.; viscosity Saybolt 300 to 800 at 100 deg. F.; gravity Baumé 19 to 28; carbon 0.05 to 0.2; sulphur none.

Oils can be classified as animal, such as lard, tallow, neat's foot, horse fat, sperm whale, shark, porpoise, etc.; vegetable, such as olive oils, rape seed, colza, cotton seed, castor, palm oil, etc., and the pure mineral oils. With the simple engine room tests available to the operating engineer at little cost, it is possible to determine if the oil purchased is as represented, and select the one most suited to a particular condition. The output necessary for making laboratory tests involves the use of an elaborate chemical outfit with complicated and delicate instruments which even then may fail in achieving workable results. A far simpler outfit can be purchased for a few dollars at any good store. There is no intention to indicate that these tests are accurate in the sense of determining the commercial value of lubricating oils, greases, etc., and good judgment and caution must be taken in making them. They must not be tried with highly volatile oils, such as gasoline, naphtha and benzine; otherwise they are perfectly safe if carefully handled.

The outfit required consists of an ordinary tin or iron pan about 10 or 12 in. in diameter and 3 or 4 in. deep, a couple of tin cups, a common thermometer, a high-grade thermometer that will read at least 500 deg. F., a gallon of clean sand, several clear 4-oz. glass bottles, a large sheet of tin or plate glass to work upon, some sheets of red and blue litmus paper, a quart or so of gasoline, a few pounds of cracked ice, washing soda, salt, caustic soda and lye, a small pane of glass painted black on one side with a solution of lamp black and shellac, and a small hot plate, stove or burner to heat the oils.

Flash Point or Burning Test—Pour some of the oil to be tested into one of the metal cups until the cup is nearly full. Place the cup in one of the tin pans, and cover the sides with sand until the pan is full. Place this over the heat and immerse the bulb of the 500-deg. thermometer in the oil. When the temperature has reached about 200 deg. F., light the end of a string and pass it over the top of the oil without touching it. Repeat this as the temperature rises at every 2- or 3-deg. rise. At a certain temperature the oil vapor will ignite with a quick flash and a blue flame. Note the thermometer reading, for this is the flash point. This test should not be made in a strong light or in a dark room, as either

LOWERS MAINTENANCE COST

By J. L. INGRAM

Station Engineer, Gulf Pipe Line Company

will give a false reading. A flash point obtained by this method will be about 15 deg. higher than by the laboratory cup test.

Continue heating the oil until it ignites and burns on the surface. The thermometer will then give the burning point.

Saponification Test for Vegetable or Animal Oils Mixed with Mineral Oils—Place one pint of the oil in the small iron boiler or sauce pan, add 1½ oz. of caustic soda or lye, boil the mixture for 30 min., then set aside and let cool. After cooling examine the surface closely. If it is covered with a soap or soapy looking composition, it contains either animal or vegetable fats. Place a few drops of the oil on the black painted glass and hold it to the light at different angles. If there is mineral oil present, it will show the colors of the rainbow.

Congealing Test—Fill one of the cups about half full of the sample and place it in the pan, filling around the cup with cracked ice mixed with rock salt and sal-soda. Cover the completed test tightly with rags or newspapers to exclude air until the oil has congealed. Then remove the freezing mixture from the pan and fill the pan with hot water. When the oil in the cup starts to melt, immerse the bulb of the thermometer and note the temperature—the congealing point.

Free Sulphuric Acid—Fill the cup half full of the sample. Place in the pan and fill around the cup with sand. Heat to 300 deg. F., and maintain that temperature for 15 min. After cooling completely, compare the color with that from which the sample was taken. If it is considerably darker than the original, it contains sulphuric acid and is unfit for use in hot cylinders or bearings.

Precipitation Test for Paraffine, Gum Waxes, Etc.—Place an ounce of each of the oils to be tested in separate clear bottles. Then pour 2 oz. of clear gasoline on top of the oil in each bottle. Shake the mixture until the gasoline and oil are completely mixed, and allow to stand for three hours. If there is any amount of precipitation or sediment in the bottom of the bottle it is a sign that the oil has been treated to obtain artificial viscosity and should be rejected. If a graduated test tube is available, the correct percentage can be obtained. The percentage of water in the lot of fuel oil can be obtained by taking 50 c.c. of oil and 50 c.c. of gasoline and letting them stand together for 2 hours. If 2 c.c. of water settles out, 2/50 or 4 per cent of water is present.

Acids and Alkalies—Melt a spoonful of the oil or grease to be tested in five times that quantity of boiling water. Then seep a piece of red litmus paper in it for at least 15 min. If the paper remains red, the grease or oil is acid. If the paper changes quickly to a dark blue, the sample is alkaline, but if it changes color very gradually to a light blue, the oil is neutral. As a good check on the above test, use a piece of blue litmus paper in the same way. If the color of the paper does not change but remains dark blue, the mixture is alkaline. If it turns red quickly, the test is acid, but if the paper changes gradually to a pale red the solution is neutral.

Viscosity—This test is only comparative, but will assist the engineer to select the oil of the highest viscosity. Pour several drops of the samples to be tested onto the small pane of glass while it is perfectly level. Caution should be taken to get the same amount of each oil. Raise one end of the glass gently and insert a 1-in. block under it. The oil that reaches a given mark on the lower end of the glass last is the one of greatest viscosity. The precipitation test should then be made for artificial viscosity. Greases cannot be tested in this manner, but as viscosity is not as important as in lubricating oils, the experienced engineer can rub a small quantity in the palm of his hand and just about tell the quality.

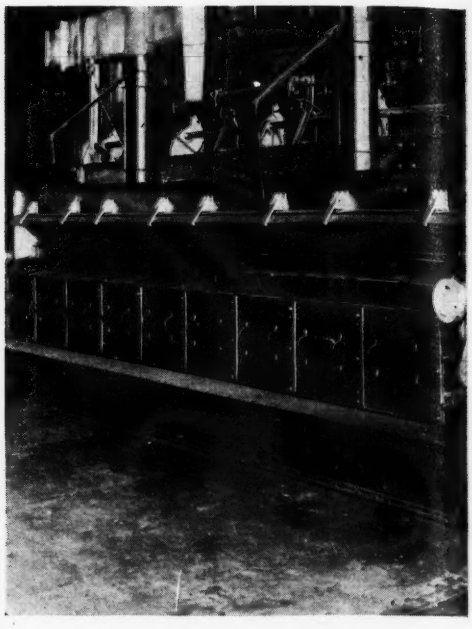
In fuel oils the usual temperature for testing is 60 deg. F. Hydrometers are usually provided with a special scale for figuring temperature variations. The specific gravity is found by dividing 140 by 130 plus the Baumé degrees. For example, if the hydrometer registers 30 deg., this added to 130, and divided into 140, shows a specific gravity of 0.875.

Hard deposit obtained from 200 hours of centrifuging lubricating oil with a De Laval No. 600. Between 8 and 10 oz. of sludge was obtained after 64 hr. of centrifuging 300 gal. at 20 gal. per hr.

Lubrication in the diesel engine is indeed important and is an expensive problem unless properly handled. It is just as important in a small engine as in a large one. Therefore, no trouble or precaution that can be taken to prevent getting an incorrect grade of lubricating oil is too great to be used to attain the ultimate goal.

While the oil tests here presented may seem somewhat crude to the laboratory trained engineer, they do give a definitely useful general idea of the value of a given oil for deisel lubrication. It is obvious that insistence on the more scientific methods of testing would in many cases mean that the engineer would operate entirely in the dark as far as his lubrication is concerned.

Accuracy and wide range of speed control are essential in a wide variety of power-plant operations if the demand for highest efficiency is to be answered. This article will assist engineers in determining the best combinations of equipment for economic speed regulation.



VARIABLE-SPEED TRANSMISSIONS

SOLVE SPEED-CONTROL PROBLEMS

CONTROL of operating speeds is an important factor in most industries. Not only is this true of manufacturing operations, but it also applies within the plant supplying steam and power to the processes. Wide ranges of speed are required for stokers, pulverized-coal feeders, draft fans, and to a lesser degree for boiler-feed and other pumps. The quantity and quality of a product and the efficiency with which it is produced are frequently influenced to a large degree by the adjustability of the drive speed. In power plants the economy of combustion processes depends upon the ease with which the speed of the plant's auxiliaries may be controlled. These requirements of speed adjustment are taken care of in several ways.

Speed Ranges of 1–6 By Field Control

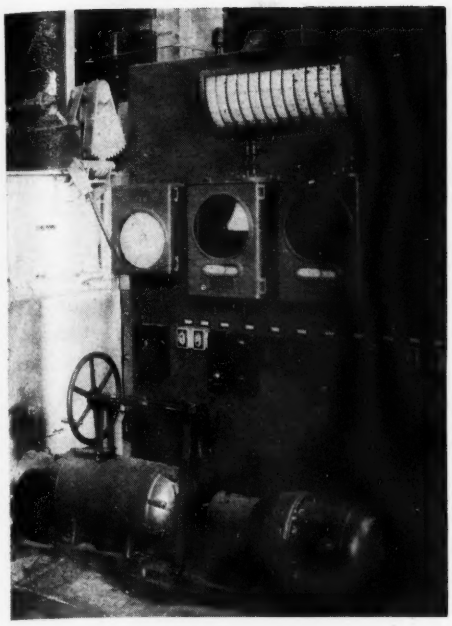
Where direct current is available, motors may be had with speed ranges as high as 1 to 6 by simple field control. This is sufficient to meet a large percentage of applications requiring speed adjustment. With variable-voltage control almost any speed range is possible, whether the system be direct or alternating current. This system, however, requires a separate generator for each driving motor, consequently the cost of such applications is so high that they are not generally economical except in large-size units or for special cases where factors other than installation cost influence the problem.

Alternating-current motors do not lend themselves as readily to speed control as do the direct-current shunt types. The squirrel-cage motor is the most simple and sturdy type that has been devised, but it is inherently a constant-speed machine. All means of obtaining adjustable speed with alternating-current motors leads to designs with slip rings, commutators or both. Even with these the speed range is not comparable with that of the direct-current shunt motor, and they are generally more complicated in their design and require a more elaborate control.

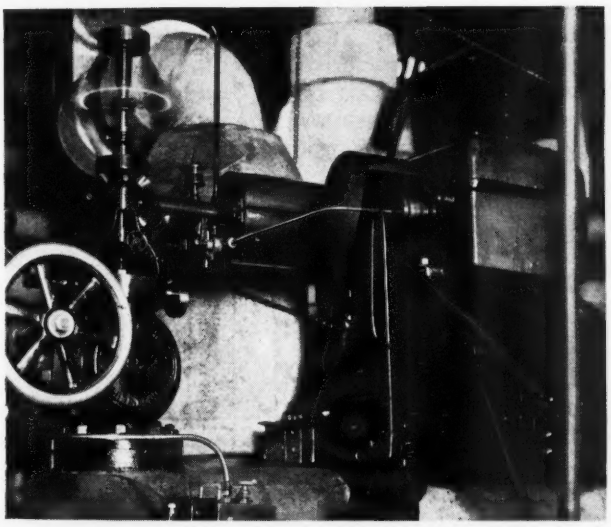
There are many adjustable-speed applications which can be met satisfactorily with some form of variable-speed alternating-current motor. On the other hand, because of the wide speed range or close speed adjustment needed, alternating-current motors cannot meet the requirements for many applications. This is also true of direct-current motors where a wide speed range is desirable. These applications are generally more economically served by a constant-speed motor and some form of variable-speed transmission. Several types are available that give an infinite number of speed increments between a maximum and a minimum value. Such speed adjustment is obtained in the different types of transmissions by:

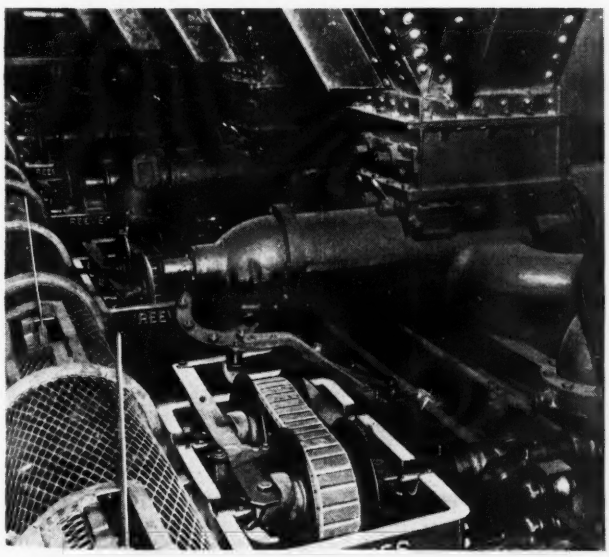
1. Sliding friction disks by which an infinite number of speeds can be obtained from a maximum down to zero, and reverse.
2. Flat belt on two opposing parallel cone pulleys that may be shifted along the cones to vary the speed between fixed limits.
3. V-shaped belts on V pulleys, the diameters of which may be adjusted to provide a speed range as high as 16 to 1. By use of a special attachment this type can also be made reversible.
4. Conical-shaped rollers running in an adjustable race so that the rollers can be made to run on different diameters.
5. Special devices such as variable-throw eccentrics with constant-throw clutches and other mechanical movements, including sliding links and gears.
6. Hydraulic types, consisting of a variable-displacement pump supplying a constant-displacement motor, to give any speed in either direction from zero up to that of the pump's input shaft.

Variable-speed transmissions may be had for either



Constant-speed motor and variable-speed transmission drives traveling-grate stoker with a speed range of 6 to 1





(Top)—Variable-speed transmission applied as a governor drive to control the speed of a paper-machine steam-engine drive. (Below)—Constant-speed motors drive pulverized-coal feeder through variable-speed transmissions

floor or ceiling mounting. They are built in both horizontal and vertical designs to suit the machine which they drive. When necessary, a speed-reducer may be combined with the variable-speed transmission to accomplish speed reduction as well as speed adjustment. For example, with a 1,200-r.p.m. motor driving the unit, the speed to the transmission's input shaft is reduced to 150 r.p.m. and the output shaft's speed adjusted from 150 to 30 r.p.m. Such a unit gives a maximum speed reduction of 40 to 1 and an adjustable-speed range of 5 to 1. The sizes in which variable-speed transmissions may be had vary with the design and speed and range from fractional to several hundred horsepower in size.

Control of Units

Control of the units may be manual by a hand wheel, lever or other device. It may also be by electric push-button from a remote point. A tachometer is provided, if necessary, to indicate the speed. Full automatic control may also be had, such as is required for automatic combustion control or for other processes.

Almost any reasonable speed range is possible with this equipment in infinite steps. Power transmission is practically positive, there being very little slippage when the drive is properly selected, installed and maintained.

The horsepower variation of variable-speed transmissions is less than their speed variation. For example, with a design having a speed ratio of 8 to 1, at a maximum speed of 664 r.p.m. the rating is given as 30 hp. and 10.5 hp. at 83 r.p.m. for the output shaft.

Their speed remains constant at each adjustment and does not vary with load fluctuations as does the speed of some types of variable-speed motors. Power consumption varies according to the speed and character of the load driven. With a constant-torque load, power input varies practically in direct proportion to the speed, whereas with a wound-rotor type motor the power input remains practically constant at all speeds.

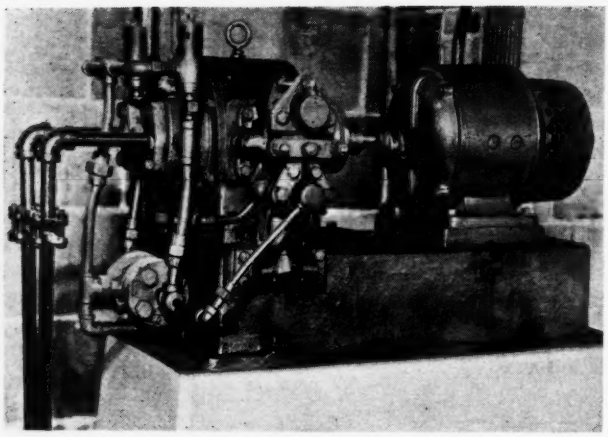
Efficiency of Variable-Speed Transmissions

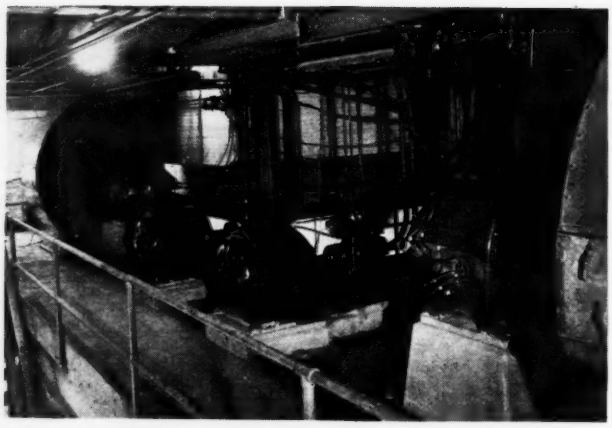
The efficiency of these transmissions varies with the type, design, size and the speed of the output shaft. Some mechanical designs have a full-speed efficiency at rated load of over 95 per cent, and better than 80 per cent at minimum speed. Hydraulic types will have an efficiency of from 80 to nearly 90 per cent over a wide speed range with constant-torque loads.

But, variable-speed transmissions should not be judged on efficiency alone. There are many other factors that must be taken into account, such as first cost, operating costs, speed range, control and the adaptability of the unit to the drive.

In considering the efficiency of a variable-speed transmission it should not be overlooked that the efficiencies of motors also decrease as their speed is decreased. Also, the power factor of the motor may be of greater importance than its efficiency if power is purchased on a rate schedule that has a power-factor clause. The power-factor of alternating-current motors, excepting the synchronous type, decreases rapidly as speed is reduced.

There are many drives for which the multi-speed or the wound-rotor motor is satisfactory for speed-adjustment problems, but there are many others where a simple constant-speed squirrel-cage motor and a variable-speed transmission will be most economical. This combination permits the use of a high-speed, high-





(Top)—Motor-driven variable-displacement pump for a hydraulic variable-speed transmission on a clinker-grinder drive. (Below)—In the center are two motor-driven variable-displacement pumps on hydraulic transmissions applied to under-feed stokers

efficiency motor that has a comparatively high power factor. The motor can usually be started by connecting directly across the line, allowing the use of a simple and inexpensive control. It may be mounted directly on the transmission to provide a compact unit. As the efficiency of both the motor and the transmission are comparatively high, the combined losses of the two will be less than many of the variable-speed motors and the cost of the former will compare favorably with that of the latter. Because of improved efficiency of the process using variable-speed transmissions, the power consumption per unit output may be considerably less than with other forms of drives.

Power saving, however, is only one consideration, for the increase in output and the improvement obtained in the product's quality may be of greater importance.

How to Select Transmissions

When selecting variable-speed transmissions the following information should be available: (1) kind of machine to be driven, (2) speed of machine's input shaft and if reversible, (3) how shaft is to be driven, whether direct-connected or by flat belt, V-belt, chain or gear, (4) location of transmission relative to the driven machine, (5) maximum and minimum speeds wanted on machine's drive shaft, (6) maximum torque and at what speed, (7) continuous or intermittent service, (8) if transmission is to be motor driven, motor's horsepower rating and speed, (9) how motor is to be connected to transmission and dimensions of drive, such as width of belt, diameter of pulley or width and pitch of chain? (10) will transmission be mounted on floor or ceiling, (11) any space limitations, (12) any extremes of temperature or unusual conditions, (13) is cooling water available if high-temperature conditions must be met, (14) what type of control is desired, such as manual by handwheel, remote by push button, or full automatic?

Torque Usually Constant

For the average installation the torque is constant or decreases with the speed. In such installations if the transmission is selected for the load at maximum speed it will be satisfactory for loads at other speeds. There are some drives where maximum load occurs at the low speed. For such cases the variable-speed transmission must be selected for the slow-speed conditions.

Mechanical types of transmissions are generally rated in their maximum continuous capacity without any allowance for overloads. Where a transmission is to be motor driven, its capacity should be at least equal to that of the motor. In most cases a variable-speed transmission should be selected with a normal rating 10 to 50 per cent greater than that of the driving motor. This excess capacity is to allow for severe starting conditions, overloads and characteristics of the load. For an application that develops repeated overloads and shock, a transmission with a greater margin of safety is required than on an application where load is constant. It is desirable that the constant-speed shaft of the transmission be operated at the manufacturer's recommended value. The speed of this shaft, however, can be reduced below its rated value, but the horsepower rating of the transmission must also be reduced.

Hydraulic Types of Transmissions

The hydraulic types are designed for speed ranges up to some maximum value such as 0 to 900 r.p.m. or 0 to 400 r.p.m. Their horsepower rating is based on continuous 24-hr. daily service. Intermittent rating may be increased 25 per cent over the continuous rating and for momentary overloads the working torque may be increased 150 per cent over normal rated value. When slow and creeping speeds are required, torque is more important as a factor in rating than horsepower. For such cases one manufacturer recommends a size machine be selected that will meet the requirements at about 350 lb. oil pressure. It is also suggested that for continuous duty about 400 lb. is about the best oil pressure to use.

So many conditions control the application of variable-speed transmissions that it is practically impossible to provide a general specification for their selection. When applying these equipments, if there are any doubts about the installation it is advisable to consult the manufacturers. They have had wide experience and are in a position to give expert advice.

Acknowledgment is hereby made for assistance rendered in the preparation of this article by Reeves Pulley Company, Columbus, Ind.; Lewellyn Manufacturing Company, Columbus, Ind.; Link-Belt Company, Chicago, Ill.; Stephens-Adamson Mfg. Company, Aurora, Ill.; Universal Gear Corporation, Chicago, Ill.; Weiss Engineering Corporation, New York City; Waterbury Tool Company, Waterbury, Conn.; American Engineering Company, Philadelphia, Pa.; and the Oil Gear Company, Milwaukee, Wis.

HYDRO plants, particularly low-head run-of-river developments, can perform distinct services when operating in parallel with steam stations. These include: generation of energy, replacement of steam-plant investment, greater flexibility in scheduling boilers and standby capacity, rapid mobilization of reserves, maintenance of frequency

COMBINING HYDRO WITH STEAM IMPROVES POWER-SYSTEM ECONOMY

By CARROLL F. MERRIAM

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IT IS not surprising that the lay mind is confused by the conflicting arguments in favor of either water-power or steam-power developments. On one side pleas are made to develop all possible hydro for conservation of natural resources, national economy and exercise of public rights to enjoy these sources of apparently cheap power. On the other hand, claims are set forth that there is no further need for water power because energy can be produced more cheaply by steam. From the viewpoint of engineers charged with the maintenance of service to the public, these so-called "competitive" sources are not rivals after all, but are partners. It has been found that by a well-balanced combination, a power supply can be secured that generally is cheaper than either one alone.

The solution to the problem is, then, to keep steam and hydro as far as possible in proper proportions, to work out practical operating schemes that develop fully the complementary advantages of both, and to exercise foresight to provide for future needs. This matter has become of such great importance to the utilities that K. M. Irwin of the Philadelphia Electric Company and J. D. Justin of the United Gas Improvement Company presented at the recent semi-annual meeting of the American Society of Mechanical Engineers an excellent paper on this subject.

This paper deals primarily with methods used in evaluating the service which hydro may render to a mixed system, in order that the relative merits of the two sources can be correctly judged when deciding where a utility shall turn for additional capacity to meet increasing system demands. An abstract of this paper appeared in the July number of *Power,* page 46.

The authors bring out clearly the change in attitude towards this economic problem, and point out the fallacy of the past in regarding hydro simply as a fuel saver without firm capacity value other than the 24-hr. continuous power at time of minimum flow. They show that when hydro feeds into a large utility system, it has firm capacity far in excess of that corresponding to minimum flow.

Companies striving for a cheaper supply of power and energy have sought this solution entirely on economic grounds, and their engineers, after careful study, have come to realize possibilities of steam and hydro working in combination. Conditions in the eastern part of this country have been particularly favorable for the application of these principles, and it is here that hydro is still being developed as total system requirements increase. There is a more or less definite ratio between the amounts of steam and hydro capacities that will best suit a given power situation. This ratio depends upon natural laws and is governed by elements which enter into the total cost of production.

Much misunderstanding has resulted from comparative studies regarding the relative costs of hydro- and steam-generated power. These lead almost invariably to the conclusion that it is only where steam is at a distinct disadvantage that hydro can be considered. The assumptions on which such estimates are based appear to be perfectly fair and unprejudiced, and so if taken at their face value show definitely that hydro's day is over. In spite of such convincing proof, in normal times, hydro developments continue to be made and there must be some fundamental reason to justify them.

Near Niagara Falls, the industrial district centering about Buffalo is supplied with a large amount of steam-generated power. On the other hand, it is equally true that large hydro plants are on the systems interconnected with cities such as Pittsburgh, Philadelphia and Baltimore, all favored with respect to a cheap supply of coal and cooling water. Furthermore, interconnections are now underway to bring hydro power to New York City and Washington, D. C.

The fundamental difference between the economics of hydro and steam generation is that hydro involves a high first cost but low operating expense, in contrast to the comparatively low first cost and high operating expense of steam. For this reason a hydro company generally expends a large portion of its gross revenue for bond interest and other fixed charges. A steam plant has a smaller proportion of fixed charges but a relatively

higher cost for direct operation. To make a comparison between the two sources of power it is necessary properly to evaluate these two elements, fixed charges and direct operating costs.

Too frequently attempts are made to assume a load factor and distribute the investment per kilowatt to give a cost per kilowatt-hour and to make comparisons on such grounds between hydro and steam. Such comparisons are misleading because when steam and hydro operate together they do not have the same load factor. The load is proportioned so that one works to the advantage of the other, making their combined economy better than that of either alone.

Low-head developments have such a large part of their total cost in dams, water rights, etc., that once these are provided additional plant capacity costs comparatively little, and in fact compares favorably with steam-capacity cost. This may not be true to such an extent for high-head plants where the cost of penstocks, pipe lines and tunnels represents a relatively large part of the total. In this case the incremental cost may still be high, since added generating equipment may require additional outlay for the water conduits.

In the low-head projects incremental cost is comparatively low and apparent over-development, if judged by the ratio of plant discharge capacity to minimum river flow, becomes economical. Little is added to the investment, and if use can be made of this extra hydro capacity to replace steam or to delay the system steam-construction program, hydro plants may be justified because they not only have low operating cost, but save fixed charges on investment in steam plants that would otherwise be necessary.

Although a kilowatt of hydro generally costs more than a kilowatt of steam, nevertheless by this double duty hydro can frequently overcome the disadvantage of higher installation cost, even where the fuel cost may be small. An excellent example is Baltimore, which is within easy haul of the coal mines of Pennsylvania and West Virginia, which constitute the country's principal sources of high-grade coal. Because of this there might appear to be little opportunity for development of hydro resources on the Susquehanna River or in the State of Pennsylvania. Nevertheless the capacity in hydro plants operated by member companies of the Pennsylvania Electric Association increased from about 150,000 hp. in 1923 to over 750,000 hp. in 1930. The Safe Harbor plant, recently placed in operation, with but four units of the six forming the "initial development," adds to the latter figure an amount greater than the entire capacity in 1923.

Inasmuch as hydro generally costs more per kilowatt installed than steam capacity, it might seem impossible that hydro could be considered in districts where power can be generated from low-cost fuel. However, as previously mentioned, the redeeming factor is the low operating cost of hydro. If it can replace the production cost of corresponding steam energy and at the same time avoid investment in steam plants that would otherwise be necessary, it is possible under many circumstances to justify the development of water power. The two factors, operating cost and fixed charges, come into a delicate balance which has been but little appreciated until recently.

When operating on a utility load curve it is necessary to supply the peaks of the load but a few hours a day

A GROUP of French engineers visited the United States and Canada in the summer of 1931, through appreciation of the value of international contacts on the part of M. Albert Petsche, president of the Union d'Electricité of Paris. Lest the visitors get the impression that hydro plants were being built with capacities far in excess of that apparently warranted by minimum stream flow, a memorandum was prepared for them setting forth the economic factors that control hydro developments in America. A few copies of these notes were circulated among prominent American power engineers. Their comments were so favorable that it was decided to expand the memorandum into this article

or a week in order to take the place of a considerable amount of steam capacity that would otherwise be required. Even at times of minimum flow, water can be allowed to accumulate in the pond during off-peak hours to supply this peak load. If there were sufficient water to generate 10,000 kw. for 24 hr. continuously it would be possible to produce 120,000 kw. for two hours, or 240,000 kw. for one hour.

Whether a hydro plant is serviceable in replacing steam depends principally upon the size of the system and the sharpness of its peaks. The larger the system the greater are the possibilities for fitting the available hydro kilowatt-hours into the weekly or daily load diagram so that water-power replaces a large amount of steam capacity. In such a case, hydro plants are entitled to credit for a saving in fixed charges on the steam plant that it would be necessary to build to render the same service. If further credit is added to that earned by the energy delivered, building a hydro plant is frequently justified. The paper previously mentioned, by Mr. Irwin and Mr. Justin, deals primarily with determining this credit from studies of flow and load.

Peak Accommodation

There is another type of peak service not to be confused with the saving in fixed charges. It is perhaps somewhat more indefinite and harder to evaluate, but nevertheless it does have a real value to a system. This might be termed the "peak accommodation." For example, there may be on a given system a number of old steam stations still kept in service, although uneconomical. They operate perhaps but a few hours a day.

It has been found that run-of-river hydro plants like Safe Harbor and Conowingo have sufficient pondage to regulate the use of water throughout the week. A little less energy may be generated in one part of the week in order to conserve water for the remaining part and permit an uneconomical steam plant to be shut down

cold for several consecutive days. This is desirable for boiler-room economy, as banking losses are reduced.

Boilers should be so scheduled that when once shut down they should not be required in service for several days. Economy in steam operation appears to be determined more by boiler-room requirements than by the turbines. If sufficient pondage is available the daily discrepancies in load estimating may be shifted to the hydro plant so that the base-load steam plant operators know farther in advance what load will be expected of them. Thus will be seen that even when hydro capacity is installed far in excess of the continuous power at time of minimum stream flow, it is possible by manipulating pondage to utilize excess capacity to reduce the over-all cost of energy.

The fourth service, maintaining system frequency, can be rendered to good advantage by low-head hydro plants, particularly if the water passages are short. Modern steam plants have a surprising ability to carry load swings, but at a considerable sacrifice in economy. High-head plants are often at a disadvantage on account of possible water hammer in penstocks and long water passages. The low-head plant does not have this difficulty to anywhere near the same extent, and therefore load changes are far less serious than with either steam or high-head plants. Furthermore, high average efficiency under varying-load conditions in a hydro plant is mainly a matter of keeping the units properly loaded.

The Kaplan turbine marks a distinct progress in the design of wheels for supplying loads with high average operating efficiency. Safe Harbor is noteworthy as the first American plant equipped with such wheels having physical dimensions in any way approaching those of modern European plants. Although physically not as large as some units built in Europe, because of the higher head these wheels hold at present the record for power developed by the Kaplan unit.

It is important to note that the first hydro added to a system which has been previously supplied only by steam is made extremely valuable by a comparatively few hours of operation per day during minimum flow. It can fit its energy into the peak of the load curve and so replace steam capacity to an extent many times the continuous power that could be generated.

It follows, however, that as more hydro is introduced, the hours of operation for the additional units must be longer, Fig. 1. Consequently the peak value of added hydro capacity is reduced to the point that notwithstanding the low incremental cost, there is a limit to the amount of waterpower that can be used economically in a given system. As capacity is added, the revenue from the sale of kilowatt-hours per kilowatt of capacity becomes less and less, as there are fewer days in a year when there is sufficient water to operate the added capacity, Fig. 2.

From this it follows that there is a natural balance between hydro and steam, an economic ratio which remains substantially constant. For this reason further growth in system load gives opportunity for both steam and hydro. The proper balance is maintained when for given conditions the total over-all cost of power supply is a minimum.

The trend toward general interconnection of power systems is particularly favorable for hydro development, for it automatically brings hydro into systems that were hitherto supplied solely by steam. It gives hydro the desired conditions to make possible the use of cheap incremental capacity, since the combined system peaks are, except in rather rare cases, very sharp, particularly after the addition of an all-steam metropolitan district with its sharp lighting peak near Christmas. At the same time interconnection gives hydro a wider market for off-peak energy that can advantageously be disposed of during times of abundant river flow. Rivers are not all coincidentally in flood, and with the development of pumped storage as well as reservoir plants, the opportunities for widespread pooling of energy offer interesting possibilities.

To sum up, it is evident that in spite of apparent proof that it is no longer feasible to develop water resources, hydro power is being developed in accordance with economic principles which are controlled by characteristics of problems peculiar to the energy supply and type of plants common on rivers in the eastern part of the country.

Steam and hydro are not rivals, but partners. The cheapest supply may be had when steam and hydro are in proper balance, and interconnection is opening up new possibilities for hydro as the few remaining all-steam districts become joined to the general system network.

Interconnection has brought serious operating problems, but by co-operation between operating men and farsighted operating companies these difficulties are fast yielding to the advance of science and the art of waterpower development.

It is obvious that successful water-power development is dependent upon the opportunity of rendering a substantial service to a widespread market for power which is primarily supplied by steam.

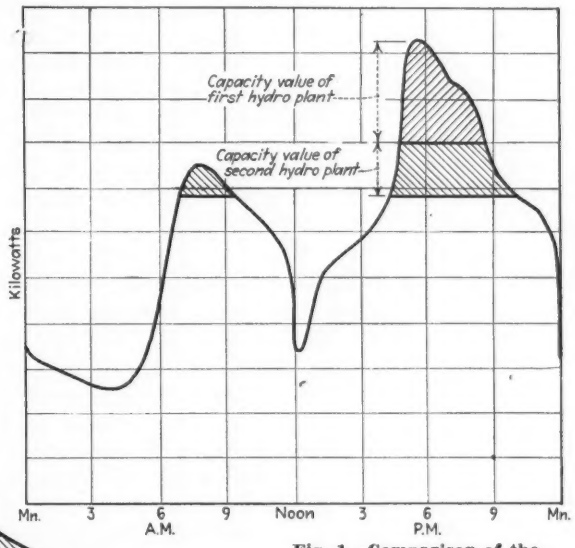


Fig. 1—Comparison of the capacity value of two hydro plants having the same available energy

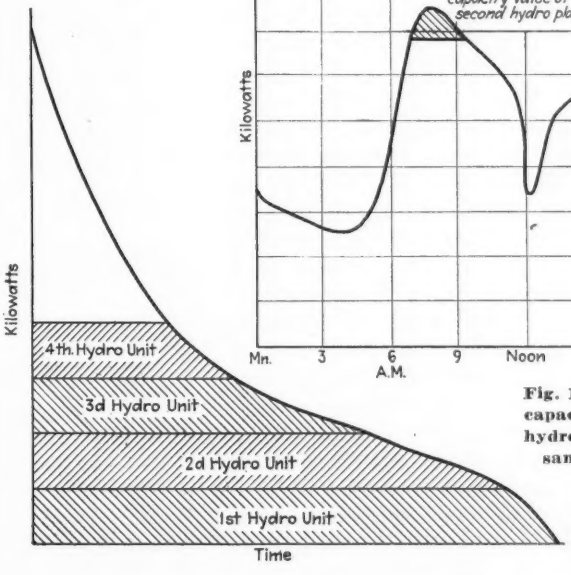


Fig. 2—Comparison of energy value of several hydro units having equal capacities

$20,000 YEARLY REDUCTION IN PURCHASED S

BECAUSE steam and power are purchased for a building or a manufacturing plant is no reason for the engineer to assume that he has no opportunity to keep down the cost of these services. There are many instances where plants of this kind have been neglected and later have been taken in charge by capable engineers who have made large reductions in operating costs. Steam and power can be wasted in many ways whether they are produced in a private plant or purchased from a utility. This article is based on the saving made by applying intelligent engineering management to two plants in office buildings.

In one of these plants there are two 100-kw. and one 50-kw. steam-engine generating units, two steam-driven elevator pumps, and several steam-driven pumps for building services. The other power plant has a 120-kw. and a 75-kw. steam-engine driven generating units and practically the same complement of steam-driven elevator and service pumps as the first building. Steam is purchased to generate all power summer and winter, except a small amount purchased as an emergency service from the street lines.

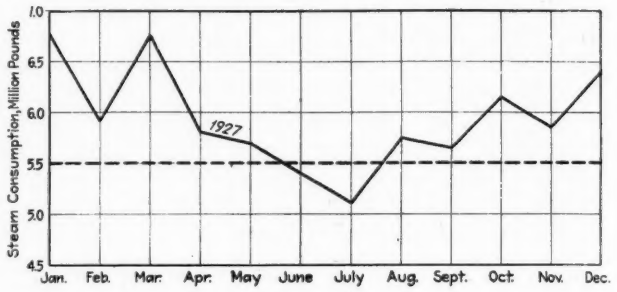
During the heating season practically all exhaust from the engines and pumps goes into the heating system. In summer most of the exhaust goes to atmosphere, except that used for water heating. The two plants are tied together electrically at the switchboards, and the heating mains are arranged in the basement so that exhaust from either plant may go to the heating system of both buildings if so desired.

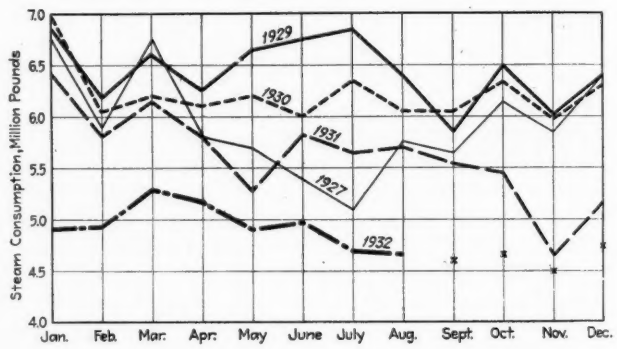
Steam is purchased on a contractual monthly demand that is established in October of each year for the following twelve months. The monthly rate is $1.00 per 1,000 lb. for the first 250,000 lb. of the contractual monthly demand. The balance of the contractual demand is obtained for $0.60 per 1,000 lb. Any excess above the contractual demand is charged at $1.25 for the first 250,000 lb. per month and any excess at $0.80 per 1,000 lb.

These rates are based on a base coal price per long ton at the plant. An adjustment is made in the rate for any increase in coal cost above that price. Under present conditions the coal charge adds from $0.025 to $0.030 per 1,000 lb. of steam.

Better to understand what the chief engineer in these plants has done to reduce steam costs it will be well first to figure a monthly steam bill. The steam consumption is obtained by multiplying the meter reading by a constant. There is a slight difference between this value and that obtained by the steam company, which uses the average value obtained from the integrator dials and the chart from the recorder. The difference between the two methods is so small that it may be neglected insofar as keeping plant records is concerned.

The meter constant must be obtained from the steam company and will vary with the size of the meter. For example, for a 4-in. St. John meter the constant will be





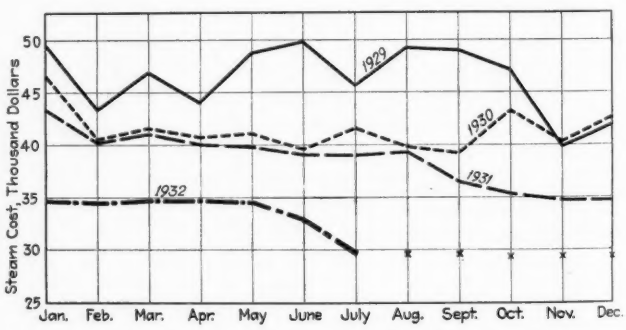


Fig. 1 (top)—Monthly steam-consumption curve for 1927.

Fig. 2 (middle)—Comparison of monthly steam consumption for different years. Fig. 3—Curves of monthly steam costs for 1929 to 1932

about 5.5 and for a 6-in. meter it will be about 6.9 to 7.7. The quality at which the steam is supplied is also taken into consideration when determining the steam consumption. This is done by multiplying the consumption, obtained from the meter, by a pressure factor obtained from the steam company. For the plants under discussion the pressure factor is about 1.037, but will vary slightly from month to month.

Assume that the reading taken from the integrator of a 6-in. meter is 4,674 and that one month later the reading is 5,024. This gives an integrated consumption of 5,024 — 4,674 = 350 units, a unit being the equivalent

STEAM COSTS

Every one is interested in keeping down operating costs, the purchaser of steam no less than he who makes his own. The method here described will assist steam purchasers in analyzing their contracts.

of 1,000 lb. If the meter's constant is 7.5 and the pressure factor is 1.037, then, the steam consumption for the month equals 350 × 1,000 × 7.5 × 1.037 = 2,722,125 lb. Assume that steam is purchased on a rate as previously given, the contractual monthly demand is 2,750,000 and the coal charge is 0.025 per 1,000 lb. Since the contractual demand has not been exceeded, it is the amount charged for in the monthly bill. The first 250,000 lb. is obtained at $1.00 per 1,000 lb., or a total of 250 × 1.00 = $250. The remainder, 2,750,000 — 250,000 = 2,500,000, will cost $0.60 per 1,000 lb., or 2,500 × 0.60 = $1,500. The coal charge is also made for the contractual demand and will therefore amount to 2,750 × 0.025 = $68.75. This makes the total monthly cost for steam 250 + 1,500 + 68.75 = $1,818.75.

Assume that the contractual demand had been set at 2,400,000 lb. per month. Then the first 250,000 lb. of steam would cost the same as in the first case. The remainder up to the contractual demand, or 2,400,000 — 250,000 = 2,150,000, would be obtained at $0.60 and would cost 2,150 × 0.6 = $1,290. The contractual demand has been exceeded by 2,722,125 — 2,400,000 = 322,125 lb. The first 250,000 lb. of this will cost $1.25 per 1,000 lb., or 250 × 1.25 = $312.50. The remainder, 322,125 — 250,000 = 72,125 lb., costs $0.80 per 1,000 lb. or 72.125 × 0.8 = $57.70.

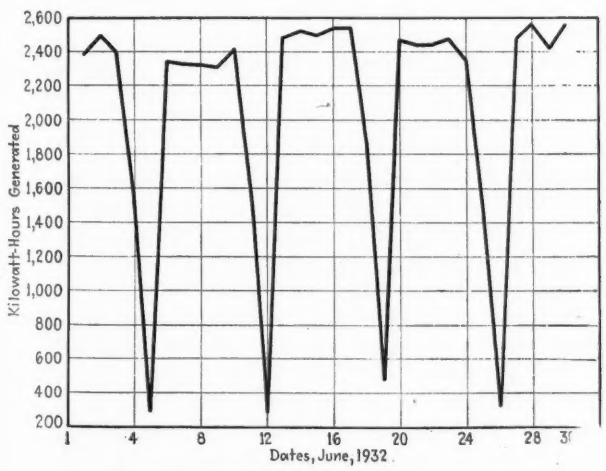


Fig. 4—Curve of daily power generation

The coal charge in this case will be on the actual consumption and will amount to 2,722.125 × 0.025 = $68.05. This makes the total monthly charge for steam equal to 250 + 1,290 + 312.50 + 57.70 + 68.05 = $1,978.25, an increase of 1,978.25 — 1,818.75 = $159.50.

This change in cost, due to the difference in contractual monthly demands, emphasizes the necessity of being able to predict this demand closely when the yearly contract is made. If the contract is made on a monthly demand that is too high, an excess charge will be paid each month for steam not used. On the other hand, if the contractual demand is too low, a high rate will be paid for steam that should be obtained at low cost.

One method used by steam companies to determine the contractual monthly demand where the user does not wish the responsibility of establishing it is to take the average consumption for the four months preceding the new contract. This at best is only a rough approximation for which the steam company cannot be held at fault. The user of large quantities of steam should be sufficiently familiar with the characteristics of his load and the factors that influence it to make a contract that will closely approach the lowest yearly cost.

Reduction in Steam Consumption

The curve Fig. 1 shows the monthly steam consumption during 1927 for two buildings previously mentioned, where the steam contract was made in October. This curve is for a year before any attempt was made to study the steam load and maintain the plant in good condition. If consumptions for June, July, August and September are used to establish the contractual demand, it will be placed at 5,540,000 lb. per month, as indicated by the dotted horizontal line. This is evidently too low to obtain the best annual rate. Placing the contractual demand, at about 6,000,000 would result in a lower yearly cost, than with the average of the four months used. Although this would have increased the number of months when the consumption would be below the contract demand, it reduces the high cost excess above the demand. With a demand varying as widely as it does on this curve, the annual cost must necessarily be high in any case.

Attention should be called to the fact that high steam consumption in some months was caused by poor condition of the plant. During periods of low consumption the plant was partly shut down and power was purchased to supply the electric load which added materially to the cost of servicing the building.

In April, 1929, the plant was put in charge of a capable engineer who immediately began to study conditions and make improvements. The steam consumption for that year, shown in heavy lines, Fig. 2, has not the deep valley that is in the 1927 curve, and also in the 1928 curve (not shown). Instead of the valley, the curve shows a peak, but this is due to keeping the plant running and generating all the power required by engines that were in poor condition. From that time on, however, the general trend in steam consumption has been downward, and the contractual demand has been gradually decreased.

In 1930, steam was purchased on a contractual monthly demand of 6,200,000 lb. This year the contractual monthly demand is 5,400,000, or an 800,000-lb. monthly reduction. This demand is too high, as it

has never been exceeded, and for the coming year it will be placed at 4,800,000 lb. The monthly steam consumption curve for 1927 has been superimposed upon those for 1929 and later, in Fig. 2. It will be observed that the consumption of 1927 obtained through practically the same range of high and low values of the loads for the four years of 1929 to 1932 indicates that not only has the steam consumption been reduced, but extreme peak loads have been eliminated.

The curves, Fig. 3, indicate what has been accomplished in steam cost reduction. Each year shows a decided decrease from the preceding one. Where in 1929 the cost was about $57,000, it will be about $38,000 in 1932, a saving of about $19,000 per year. The crosses indicated closely the position of the cost curve for the remainder of this year. Beginning with October when the new contract comes into effect the cost will drop to less than $3,000 per month and the saving next year over 1929 costs is expected to be about $21,000, which is equivalent to over 33 per cent reduction.

This reduction has been obtained by an intelligent study of those factors that influence the steam consumption and putting the plant equipment in good working condition. Practically no new equipment has been added.

During this period of decreasing steam costs, operating costs exclusive of labor have been reduced about 80 per cent, from $9,990 in 1929 to an expected cost in 1932 of not over $1,780. Although the amount of labor has been increased about 10 per cent and the wage scale increased, the cost has been decreased, because of practical elimination of overtime work. The plant has been put in good condition, and by careful inspection, defects are detected and repaired before they have a chance to develop into unexpected failures.

Even though the plant is lacking in proper metering facilities, the engineer keeps a set of valuable records. A monthly curve of power generated is plotted as in Fig. 4. Such a curve will show at a glance any unusual changes in power demands, so that these may be immediately investigated for cause.

The steam meters are read daily at 7:00 a.m., and a daily record is kept in a ledger on the form shown in Fig. 6. This record includes the date of the reading; the meter reading; the number of units, as obtained by subtracting from one day's reading that of the preceding day; the unfactored consumption obtained by multiplying the number of units by the meter constant; and the factored consumption to date, obtained by multiplying the unfactored consumption by the pressure correction factor. The factored consumption record is accumulative and shows total consumption to date in any one month. A yearly summary of steam consumption and cost is also kept on a form, Fig. 7, in the ledger. A ledger record is also kept of any unusual happenings in the plant or building that might influence the steam consumption.

A daily chart is plotted for each month's steam consumption, Fig. 5. From this chart and ledger, records are available to keep a check on the steam consumption and to detect immediately any unusual changes in demand.

The building has a small emergency power connection from the street, for which the power company makes a charge. This charge includes the use of a certain amount of power, that is used during months of highest steam consumption to help keep from exceeding the contractual monthly demand. The number of days in a month, the number of Sundays in the same period, the power load in the summer, the average outside temperature, the power load in the winter and other factors have an influence on the monthly steam consumption. By a close study of these and the steam requirements, efforts can be made to keep the peaks from exceeding the contractual demand. A record is also kept of the meter readings and the date when taken by the steam company's inspector. This is not only valuable as a check on the readings taken by the plant's engineer, but also as a check against the contractual demand being exceeded by the meter reader being a day or two late in taking the monthly reading for billing.

From the monthly steam consumption yearly charts are plotted of both steam and its cost, Figs. 2 and 3. These charts are useful not only to show the trend in consumption and cost from year to year, but they supply one of the factors that must be available if the contractual demand is to be predicted intelligently.

It is impossible to arrive at the ideal contractual monthly demand, but with intelligent records available, a study of these, along with rental conditions, possible power loads and general weather conditions, provides a more equitable value than when these studies are not made.

Although this article deals with the contracts and conditions pertinent to only two plants, it does show that there is opportunity for intelligent management of plant equipment when steam is purchased just as in a private plant. Keeping adequate records and intelligently interpreting them in plant operation is essential to low operating costs.

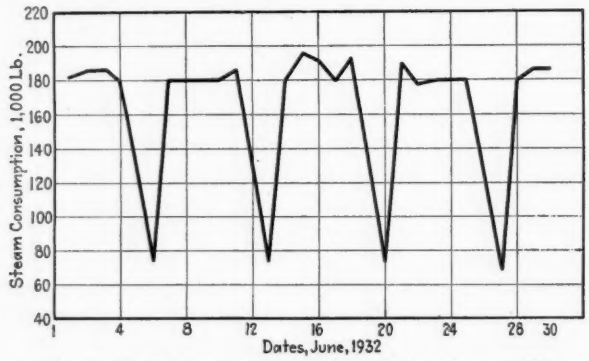


Fig. 5—Daily steam consumptions during June, 1932

RECORD OF MONTHLY STEAM CONSUMPTION

Date	Meter Reading	Number of Units	Unfactored Consumption	Factored Consumption to Date
1				
2				
3				
30				
31				
Total				

SUMMARY FOR YEAR

Month	Plant No. 1	Plant No. 2	Monthly Total	Total Consumed to Date
Jan.				
Feb.				
Mar.				
Dec.				
Total				

Fig. 6 (top)—Form on which daily record of steam consumption is kept. Fig. 7—Form on which a summary of monthly steam consumption is kept

SIX LEADING CONDENSER MANUFACTURERS APPROVE

COMMERCIAL FACTORS FOR DESIGNING SURFACE CONDENSERS

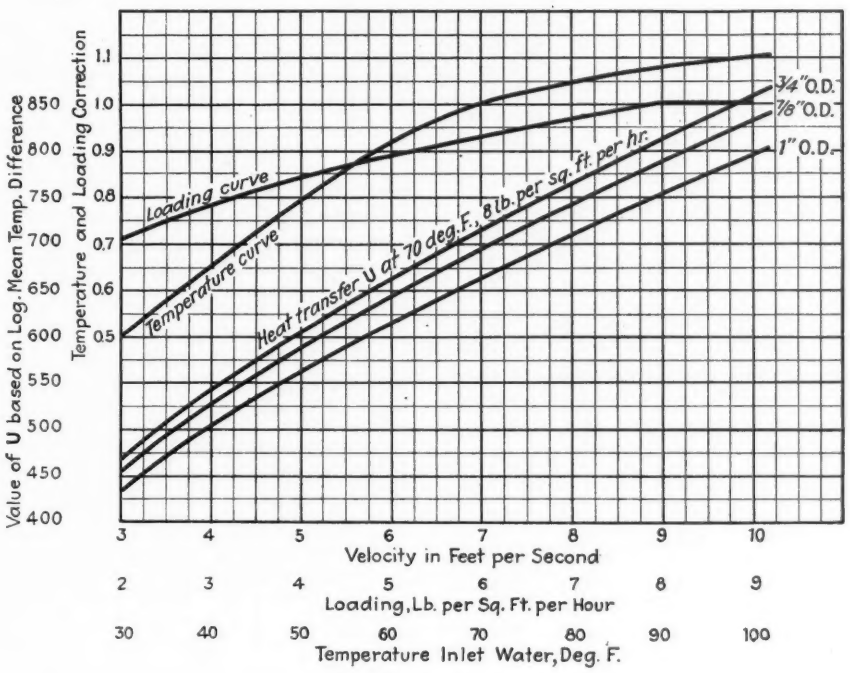

Value of U based on Log. Mean Temp. Difference
Temperature and Loading Correction
Loading curve
Temperature curve
Heat transfer U at 70 deg. F., 8 lb. per sq. ft. per hr.
¾" O.D.
⅞" O.D.
1" O.D.
Velocity in Feet per Second
Loading, Lb. per Sq. Ft. per Hour
Temperature Inlet Water, Deg. F.

Fig. 1—Commercial heat transfer curves for designing surface condensers for use in connection with turbines

As an authentic summary of general design practice this article and the curves presented have been approved without reservation by the following manufacturers of surface condensers: Allis-Chalmers Mfg. Company, C. H. Wheeler Mfg. Company, Elliott Company, Foster-Wheeler Corporation, Westinghouse Electric & Mfg. Company, Worthington Pump and Machinery Corporation

▼

THE PAST few years have shown a marked improvement in condenser design. The result of this improvement has been a noticeable increase in the over-all transfer rate obtainable in surface condensers. Naturally, each manufacturer has his own design for achieving such improvement, but it was necessary to arrive at some definite commercial values for heat transfer in order to determine the proper surface required for a given set of conditions.

It is a well know fact that test results of heat transfer on a single tube condensing air-free steam have shown coefficients of heat transfer in excess of 1,000 B.t.u. Naturally, such coefficients of heat transfer exceed any observed results in a commercially operating unit. Likewise, the coefficient of transfer from air to water through the same tube is in the neighborhood of 5 B.t.u.

In a condenser both conditions are encountered through various depths of the tube bundle, as the steam entering the condenser carries with it a certain amount of air, the greatest portion of which is due to leakage through the low-pressure gland seals and through various joints and casings which are under vacuum. The volume of air at the steam inlet is negligible in comparison with the steam volume. However, as condensation proceeds, the volume of steam is constantly decreasing and the relative volume of air is increasing until finally there is leaving the condenser only the air saturated with steam at the temperature to which it has been reduced by the air cooler. It is therefore evident that when a condenser is handling a mixture of vapor and gases having widely varying coefficients of heat transfer, the size of the condenser used for a given condition must be determined by using lower coefficients of transfer than those obtained by tests on a single tube, where practically no air was present and steam flow conditions and cleanliness of the tube were entirely different

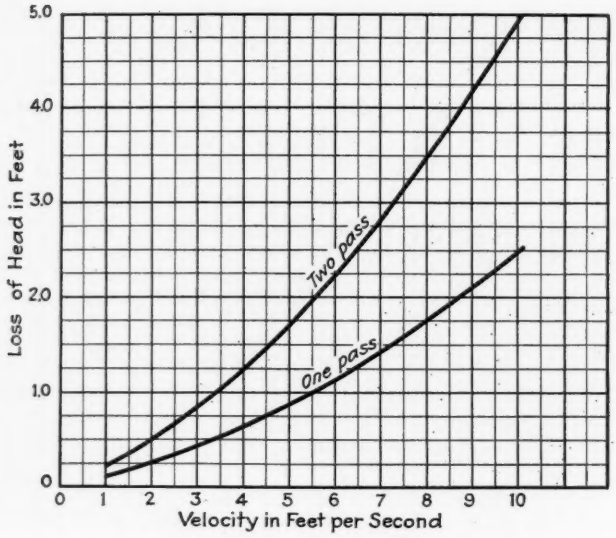


Fig. 2—Curves for determining friction in condenser tubes

from those obtained in a condenser under operating conditions.

In addition to the above variations, a slight coating of slime on the water side of a tube will materially reduce its coefficient of transfer, and inasmuch as there are comparatively few sources of circulating water supply that do not contain substances which will foul the water side of the tubes to a certain degree, due allowance must be made for this fouling in determining the amount of surface to be used. If such allowance is not made the result will be a reduced vacuum under regular operating conditions and an added operating expenses due to more frequent tube cleaning.

Realizing the necessity of establishing heat transfer rates which are possible to attain with the most efficiently designed condensers, various manufacturers have conducted extensive tests for the purpose of setting up accurate commercial values which would represent the maximum safe design limits. It is a well established fact that the coefficient of heat transfer increases with an increase in water velocity through the tubes; that it varies with the water temperature, being greater with high than with low water temperatures; that tubes of small internal diameter give a somewhat higher coefficient of transfer than those of larger diameter, owing to the greater ratio of wetted perimeter to the cross sectional area. It is also known that the condition of both tube surfaces with respect to cleanliness, pitting, and scale largely influences the transmission, the greatest transmission taking place when the tube surfaces are perfectly clean, smooth and shiny.

The results of these tests on various makes of condensers formed the basis of the coefficients of heat transfer indicated in Fig. 1. The values shown on these curves may be used in the design of surface condensers on the basis of commercially clean tubes.

It will be noted that base heat transfer curves are given for three tube sizes, viz., $\frac{3}{4}$ in., $\frac{7}{8}$ in., and 1 in. O.D. tubes, the $\frac{3}{4}$ in. tube having the highest rate of transmission, which is in accordance with the results of experiments. These curves are based upon a given temperature of circulating water, and inasmuch as 70 deg. F. water is commonly used as a base, this was used for the base curve. A correction curve is given for other water temperatures. There is also another correction curve entitled "Load Curve" and the principal use of this curve is in figuring vacuum at partial loads. Under partial load conditions, the entire cooling surface, although available, is not effectively used and to get a mean value, the heat transfer must be reduced.

The head loss through the condenser has also come under consideration and curves in Figs. 2 and 3 illustrate friction losses which can be expected in properly designed condensers. Fig. 2 covers the loss of head in feet through the tubes. These friction losses through condensers have been plotted from hydraulic tables by William and Hazen for $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$ and 1 in. outside tube diameters and for three different gages of tubes. The friction loss in feet is given for a tube 10 ft. long. For any other tube length, divide the friction loss by 10 and multiply it by the actual tube length. The value of C used in the William and Hazen formula is 130, a 15 per cent leeway having been added for fouling.

Fig. 3 indicates the water-box losses and these values take into consideration entrance and exit losses from the tubes. The total condenser friction is arrived at by adding values from curves of Figs. 2 and 3.

All of the values shown in Figs. 1, 2 and 3 are considered as the proper commercial values to be used in the design of surface condensers, and have been arrived at as a result of interchange of information between various manufacturers. These curves are used by and have been the basis for many installations made by the following companies: Allis-Chalmers Mfg. Company, C. H. Wheeler Mfg. Company, Elliott Company, Foster-Wheeler Corporation, Westinghouse Electric & Mfg. Co., and Worthington Pump and Machinery Corp.

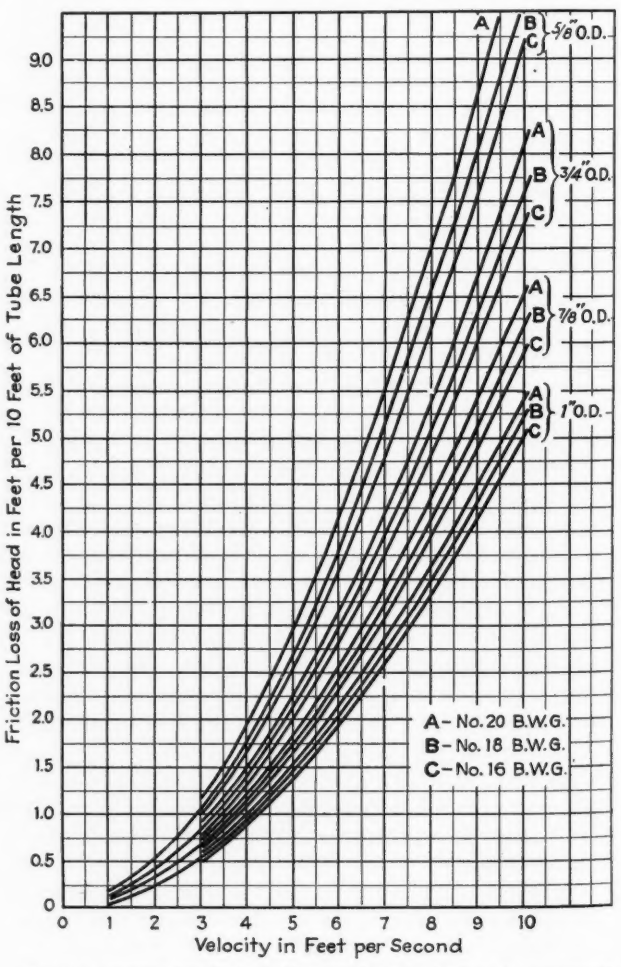
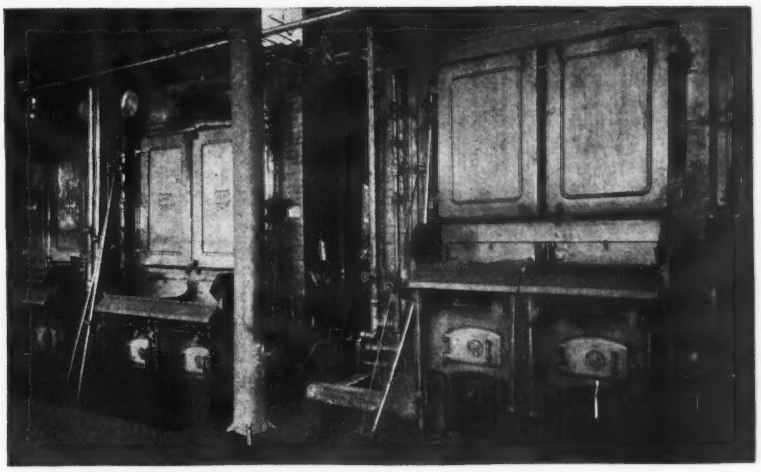


Fig. 3—Curves for determining water box losses in condenser



The pitting necessary to install two of the stokers is shown at the left

SAVINGS

PAY FOR STOKER IN TWO YEARS

By J. G. BERGER

Consulting Engineer, Newark, N. J.

COST of fuel for producing steam at the Brooklyn Yarn Dye Co. was reduced by eleven cents per 1,000 lb. by changing from hand firing to stokers and by using a mixture of bituminous coal and anthracite dust.

In December, 1930, Brooklyn Yarn Dye Co., Inc., after careful check-ups with a flowmeter on the boiler feed line and on weights of coal taken, recognized that the cost of steam was quite high. With bituminous coal costing $7.00 per ton delivered in the boiler room, the fuel cost was calculated to be 42.33c. per 1,000 lb. of steam.

By installing stokers and changing the coal used the fuel cost of steam was reduced to 31.3c. per 1,000 lb.

During the two years considered this plant scoured, bleached, dyed and finished about three million pounds of wool yarn each year. The process consists of scouring the wool yarn by washing with warm water and soap, after which it may be dyed most colors. Yarn which is to be light colored is bleached before dyeing. All yarn is dried with steam heat and finished.

Water for scouring is heated with exhaust steam from an engine used in driving part of the mill. The dyes are mixed at low temperature and are brought to a boil with live steam introduced directly into the mixture. The wool yarn is kept moving through it on reels.

Steam was generated in three hand-fired horizontal-return-tubular boilers carrying 120-lb. gage pressure and having a total heating surface of 7,084 sq.ft.

To change over to oil firing deep pitting would be necessary for two of the boilers because of their low setting. Since at high tide water rose to a short distance below the boiler room floor this method of improving economy was abandoned. Stack capacity and settings, however, permitted easy installation of overfeed natural draft stokers which would give good economy when burning a mixture of soft coal and anthracite dust, the latter obtainable throughout the year from a coal yard in the vicinity. This method of improvement was adopted and proved to be a good investment.

The flowmeter in the feed line was installed in May, 1930, and by July 1 was in good running order. Conditions before the change-over are best represented by the records from July 1, 1930, to Jan. 31, 1931. After January the records were somewhat upset for about six weeks during the change-over period in February and March. The salient operating data for the seven months preceding the change were:

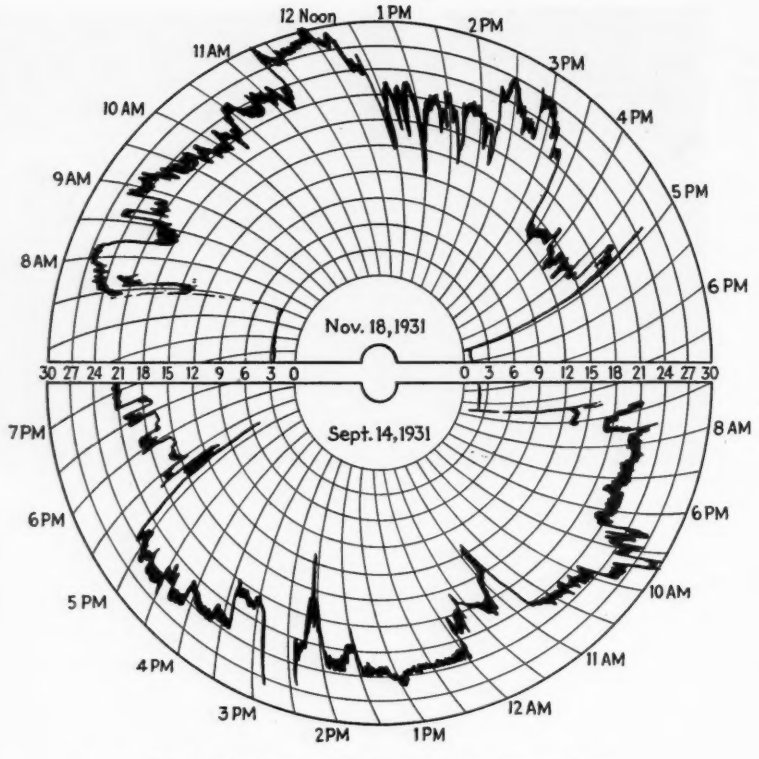
Water fed to boilers, lb.	30,099,000
Blowdown (estimated), lb.	300,000
Steam generated, lb. (30 weeks)	29,799,000
Average weekly evaporation, lb.	993,000
Coal burned (30 weeks), tons	1,802.4
Evaporation, lb. water per lb. coal as fired	8.26
Cost of coal at $7.00 per ton delivered	$12,616.80
Cost of fuel per 1,000 lb. of steam, cents	42.33

During February and March of 1931 Huber overfeed automatic stokers were installed at a cost of approximately $10,200. This figure included Ruggles-Klinge mann draft control and the charge for engineering. Stoker equipment alone cost $6,980.

Two changes were made from ordinary design in order to handle the mixture of bituminous coal and anthracite dust more efficiently. The usual ignition arch, extending 18 in. into the furnace, was replaced with a 24-in. arch. This extra length of 6 in. effectively increased the reflected heat to the top of the coking shelf, thus speeding ignition of the mixture, which, because of the low volatile content, is rather slow to ignite.

The other change from standard design was to provide a top surface for the coking shelf composed of silicon-carbide slabs 2½ in. thick. These slabs project 2 in. over the edge of the coking shelf. This material has about five times the heat transfer rate of clay and accordingly effects a much faster ignition of the fuel on the coking shelf.

Two of the boilers were set 7 ft. from the firing floor to the bottom of the shell which was too low for stoker installation. It was necessary, therefore, to do a little



Charts showing steam flow on two typical days

pitting, and as this weakened the side wall foundations they had to be underpinned. To allow for extreme high tides, all concrete used in the new work contained 10 lb. of hydrated lime per bag of cement. Shortly after the installation was completed the work was subjected to an extremely high spring tide, the highest in a good many years, which tested out the installation and showed no infiltration of water.

Comparing the new method of operation with the old did not present the usual difficulties of making allowance for production differences because the volume of production was uniform during 1930, 1931 and the first quarter of 1932.

The business is seasonal, hence there are maximum and average days with some days in each year when the plant is shut down. A typical chart is illustrated, taken on a day when the boilers were not blown down.

The following table of operating data taken after the change-over, shows the coal burned and water fed to the boilers from which a deduction is made for blowdown corresponding in amount to the period prior to the change-over.

Month of	Water Used Lb.	Bituminous Coal Lb.	Anthracite Dust Lb.	Fuel Cost per 1,000 lb. of Steam, Cents
April, 1931	3,729,000	347,300	127,600	....
May, 1931	3,984,000	407,700	75,500	....
June, 1931	3,396,000	357,900	85,000	....
July, 1931	4,965,000	498,200	124,100	....
August, 1931	4,593,000	436,200	132,000	32.9
September, 1931	5,424,000	513,300	156,600	32.5
October, 1931	4,756,000	519,500	82,600	32.9
November, 1931	4,003,000	389,000	82,500	32.9
Dec., 1931	5,187,000	484,600	165,200	31.8
January, 1932	6,801,000	575,400	189,100	29.4
February, 1932	6,542,000	592,800	152,300	31.2
March, 1932	4,355,000	409,500	115,000	31.8
Totals	57,735,000	5,531,400	1,487,500	
Blowdown Estimated.	570,000			
Net	57,165,000 lb. steam		7,018,900 lb. coal	

Evaporation—lb. of steam or lb. of coal as fired

The office records for the first four months do not segregate the coal costs, as different coals were tried and prices varied. However, the books of the company for the entire period show a coal cost of $4,800 less during the year of April 1, 1931-March 31, 1932, than for the year ending January 31, 1931, with production at the same volume.

Hence, $4,800 is the actual saving made in fuel, with no credit taken for labor, which, as before the change, consisted of a chief and two firemen. Of course, after the change-over to stokers, the chief and firemen had more time to spare and were able to do more work about the dye plant than before. This is an actual saving, although no credit is taken for it.

With 57,165,000 lb. of steam made and a saving of $4,800 the cost per 1,000 lb. of steam dropped 8.4c. for the year's average. By experimentation with various coals during the first part of the twelve months reported the saving at the end of the period is over 11c. per 1,000 lb. of steam, with a bituminous coal costing $6.20 delivered and an anthracite dust costing $2.25 delivered. Using the rate of saving obtained at the end of the period the yearly saving will exceed $57{,}165 \times 0.11 = \$6{,}288$. The savings on fuel costs alone will pay for the change-over based on the first year's operation, in: $\frac{10{,}200}{4{,}800} = 2\frac{1}{8}$ yr., a return on the investment of 47 per cent. Based on the operation brought about by the settled use of bituminous and anthracite coals, the return will be 61.6 per cent and the cost of change-over will be paid for in:

$$\frac{10{,}200}{6{,}288} = 1.62 \text{ years.}$$

Another advantage of the change-over was freedom from complaints by the Smoke Inspector of the Metropolitan Area and ability to hold steam at all loads.

▼ ▼ ▼

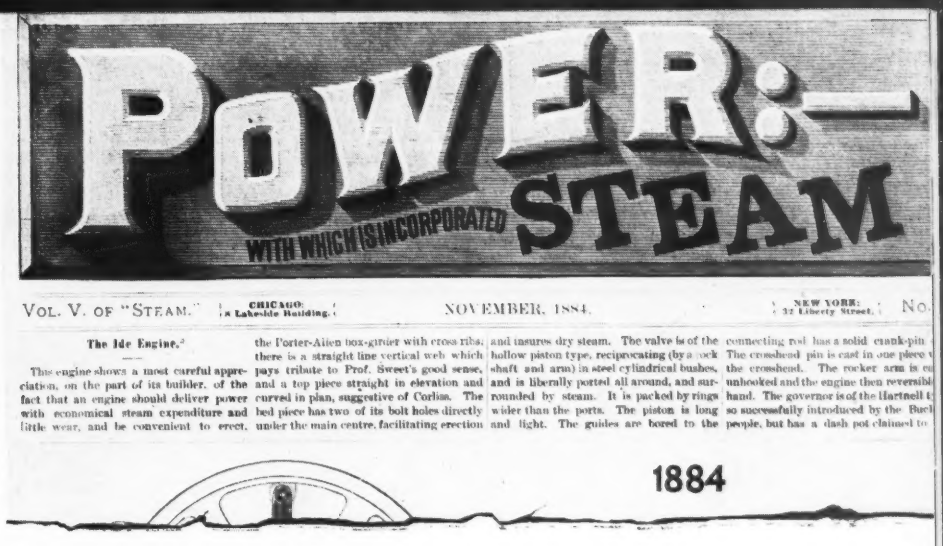
Protecting Feed Water Tanks

TESTS at the U. S. Naval Experiment Station on sixty-four samples of protective coverings which included, paints, combination of paints, primers, varnishes, oils, sprayed metals and cement wash resulted in finding only one satisfactory coating described as follows: The coating consists of a red lead-chromate primer mixed with a specially flexible vehicle and an outer coating of aluminum varnish. It allowed no corrosion to form on the test plates and its surface remained hard and smooth.

The test samples were submerged for thirty days in two baths of condensate, one containing less than 0.3 gr. of chlorine per gallon and held at 170 deg. F. for 8 hr. a day. The second bath was made of condensate containing .5 per cent normal alkalinity and 25 grains per gallon of salinity and held at 120 deg. F. for eight hours a day.

Several of the coverings prevented corrosion, but their surfaces softened to the extent that slight abrasion removed the covering and exposed the bare plate.

50 YEARS WITH THE N.A.P.E.


POWER:—
WITH WHICH IS INCORPORATED STEAM

VOL. V. OF "STEAM." | CHICAGO: 8 Lakeside Building. | NOVEMBER, 1884. | NEW YORK: 32 Liberty Street. | No.

The Ide Engine.

This engine shows a most careful appreciation, on the part of its builder, of the fact that an engine should deliver power with economical steam expenditure and little wear, and be convenient to erect, the Porter-Allen box-girder with cross ribs; there is a straight line vertical web which pays tribute to Prof. Sweet's good sense, and a top piece straight in elevation and curved in plan, suggestive of Corliss. The bed piece has two of its bolt holes directly under the main centre, facilitating erection and insures dry steam. The valve is of the hollow piston type, reciprocating (by a rock shaft and arm) in steel cylindrical bushes, and is liberally ported all around, and surrounded by steam. It is packed by rings wider than the ports. The piston is long and light. The guides are bored to the connecting rod has a solid crank-pin. The crosshead pin is cast in one piece with the crosshead. The rocker arm is ... unhooked and the engine then reversible by hand. The governor is of the Hartnell ... so successfully introduced by the Buck people, but has a dash pot claimed to ...

1884

In 1882, the National Association of Stationary Engineers was organized, the same year the publication "Steam" was organized in Chicago. Two years later "Power" was started as a magazine into which "Steam" was incorporated. In 1885 it published the first N.A.S.E. directory.

Under its later name of *National Association of Power Engineers*, the organization now celebrates its Golden Jubilee. "Power" congratulates the N.A.P.E. and recalls with pride and pleasure its past and present associations

POWER

NEWS *of the* FIELD

Long Established N.A.S.E. Now Known As National Association of Power Engineers

National Referendum Ballot Passes by 1,657 Votes Proposal by Michigan No. 7 of Detroit—Only 547 Vote Against It—Association Members of Cincinnati Hold Celebration

THE long established National Association of Stationary Engineers is now the National Association of Power Engineers.

This change in the title, proposed in the referendum ballot, by Michigan No. 7 of Detroit, was carried by 1,657 votes, 2,204 members of the association casting their ballots, and 547 voting against the proposal.

announcement, the Combined Associations of National Association of Stationary Engineers of Cincinnati gave their sixth annual banquet and dance at the Hotel roof garden, Feb. 11. ... important change in ... stage 1,800-r.p.m. machine, had been in service about two years. At the time of the accident it was being brought up above speed to test the overspeed trip gear and, it is reported, had reached a speed of 1,900 r.p.m. when the wheel gave way.

An investigation is being made into the cause of the accident and *Power* hopes to publish the full details in an early issue.

Lehigh Power, National Power & Light Companies Merge

A plan for the Lehigh Power Securities ... and the National Power & Light Company announced Jan. 26. The Lehigh ... communities in ...

1928

86

POWER:—WITH WHICH IS INCORPORATED "STEAM."

NATIONAL ASSOCIATION OF ENGINEERS U.S.A. ORGANIZED OCT. 25. 1882

Officers of the National Association of Stationary Engineers.

PRESIDENT.
JAMES G. BECKERLEG,
of Chicago, Illinois.

VICE-PRESIDENT.
R. J. KILPATRICK,
of St. Louis, Missouri.

SECRETARY.
GEORGE G. MINOR,
of Cincinnati, Ohio.

TREASURER.
GEORGE M. BARKER,
of Nashville, Tenn.

CONDUCTOR.
JOHN TRIX,
of Detroit, Michigan.

DOORKEEPER.
N. W. WILLIAMS,
of Philadelphia, Pa.

N. A. S. E. Official Directory.

[The ... tary, ... prepared ...

1885

MINESOTA.

St. Paul, No. 1.—No returns.
Minneapolis, No. 2.—No returns. Cor. Sec. Wm. McMillen, 318 Hennepin Avenue.

MISSOURI.

Carthage, No. 1.—No returns. Cor. Sec. A. P. Johnson, Water Works.
St. Louis, No. 2.—Saturday nights, at N. E. cor. 5th and Cherry Sts. Pres. G. W. Muirhead care of Wm. Burr & Co., Cor. Sec. E. P. Ambler, 210 S. 21st St.
St. Louis, No. 3.—2d and 4th Tuesday evening, at 128 East Water St. Pres. James Armstrong, 3d and Randolph Sts., St. Louis. Cor. Sec. E. H. Hill, 300 Elwood St.
Kansas City, No. 4.—1st and 3d ... Hall, 918 Main St. ... St., Cor. Sec. Henr...
Warrensburgh, ... Odd Fellows Hall, ... holzer, P. O., Cor. S...
St. Joseph, No. 6.—... 8th and Locust Sts. ... St., Cor. Sec. J. B. Le...
Cartersville, No. 7.—... Ebert, Webb City.
Sedalia, No. 8.—Me... each month, at Engine ... Main Street. Pres. Ed... Street. Cor. Sec. Ira Zi...
No. St. Louis, No. 9 ... Montgomery Streets even... Wm. Waite, 2,631 N. 10... Roehl, 2,610 N. 9th. Stree...

MARY...

Baltimore, No. 1.—Friday ... West Baltimore St. Pres... Hudson St., Cor. Sec. Th... North Freemont Street.

MASSACH...

Boston, No. 1.—No report ... 124 Oliver St.
Springfield.—Friday even... National Bank Building, M... Macready, Morris Street, Cor... Main Street.
Worcester, No. 4.—Tuesday ... Pres. George Weir, 8 Winter St... 55 Fountain St.
Salem, No. 5.—Asiatic Buildi... Saturdays. Pres. D. W. Murphy... Sec. Wm. Tott, Salem, Mass.
Fall River, No. 6.—... St. Pres. ...

TENNESSEE.

Nashville, No. 1.—Meets in Noel Block, 4th Thurs... day each month. Pres. J. W. Campbell, Cotton Mkt. Cor. Sec. Jo. Wolf, Nashville.

On the Wing.

[The following letter ... correspond...

NATIONAL ASSOCIATION OF ENGINEERS U.S.A. ORGANIZED OCT. 25. 1882

Having distributed to subordinate associations one set of the Revised Rituals, and copies of printed report of the national convention at Baltimore, I desire to notify associations that it is their duty to remit to this office one dollar for each set of five rituals, and five cents for each copy of "Proceedings" in excess of five copies furnished free.

Secretaries ... emittances by ...

1884

POWER
September, 1932

TIDE WATER *Tests* 12

TYCOL SHOWN TO HAVE

Leading turbine and Diesel oils, RE-refined by Tide Water's Special Edeleanu Process, shown to contain from 9.8% to 25.3% of sludge-forming extract

Tide Water has long known that its Special Edeleanu Process does what conventional methods fail to do...it produces *sludgeless* oil!

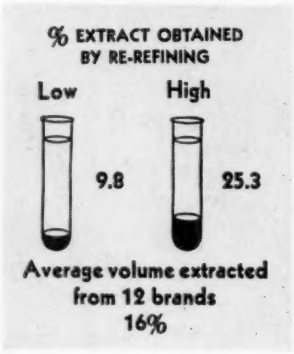
To prove this beyond doubt Tide Water bought (in the open market) 12 competitive brands of finished turbine and Diesel lubricating oils and *re-refined* them by this Process.

The results were most significant. Extracts were taken from each of these 12 oils . . . ranging from 9.8% to 25.3% of the original volume of oil!

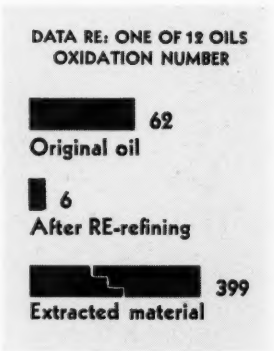
It is these extracted impurities which cause sludge, acidity, carbon . . . and premature breakdown of oil. Their oxidation numbers ranged from 144 to 399!

TESTS PROVE IMPORTANCE OF REFINING... The original average oxidation number of the 12 oils was 43. It dropped to 5 after re-refining. But it took Tide Water's Process to improve their lubricating quality...to make them sludgeless.

Here are the reasons: The Process is a physical solvent treatment. It dissolves ALL unstable hydrocarbons, found even in the best of crudes. It starts NO chemical reaction upon the components of oil, stable or unstable. It forms NO new unstable substances.



And it preserves the pure and stable hydrocarbons of highest lubricating value.



That is why Tycol Turbine and Diesel Oils, being 100% paraffine base, and refined by this Process, have purity and stability which no other oils possess. Tycol Oils have oxidation numbers ranging from 1/4 to 1/50 of those of competitive grades.

SERVICE...THE REAL PROOF... In the final analysis, it is service that counts. Everything shown in these laboratory tests is borne out in experience. Tycol oils have set up new records of performance for some of the country's leading producers of power.

Based on these records, you can depend on Tycol Oils for low acidity, low carbon deposition and better demulsibility. You can depend on them for stability, for non-sludging, long-lasting, efficient economical lubrication!

Tide Water has prepared a complete detailed Laboratory Report, "Re-refining 12 Brands of Oils." A copy of this booklet will be mailed upon request. Tide Water Oil Sales Corporation, 17 Battery Place, New York.

Competitive Oils by RE-*refining*

LOWER SLUDGE-FACTOR

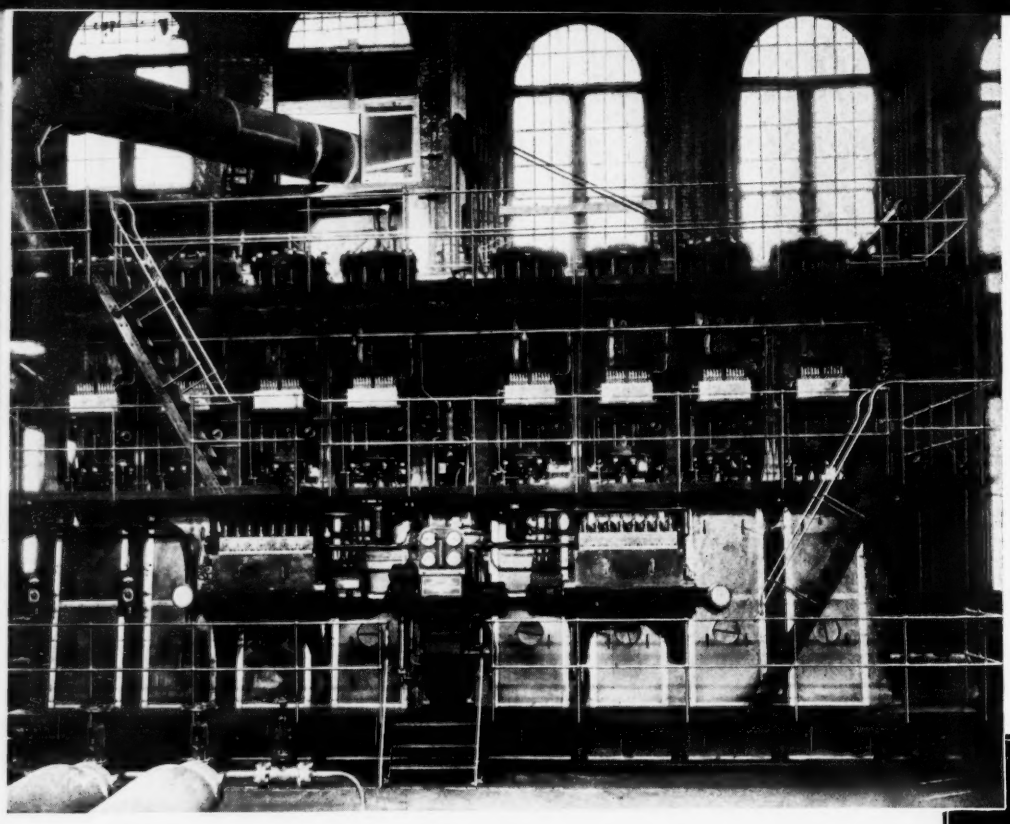
■ *The Funk Sludging Apparatus (applicable to testing light turbine oils) showing mixture of oil, water and air being agitated at 210° F, conditions comparable to actual turbine service. Every batch of Tycol (light) is tested in the machine, and its lower sludge-factor determined before shipment.*

KNOW YOUR OILS

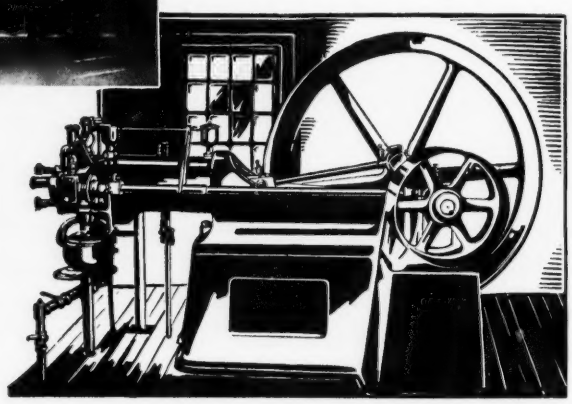
So sure is Tide Water of Tycol superiority that it is making an unprecedented offer to buyers of turbine and Diesel oils. Tide Water will be glad to *re-refine for you,* by its Edeleanu Process, a sample of the turbine and Diesel lubricating oils you are now using. Not only that, Tide Water will welcome the presence of your own technologists at the time.

INDUSTRIAL TYCOL OILS-GREASES

TIDE WATER

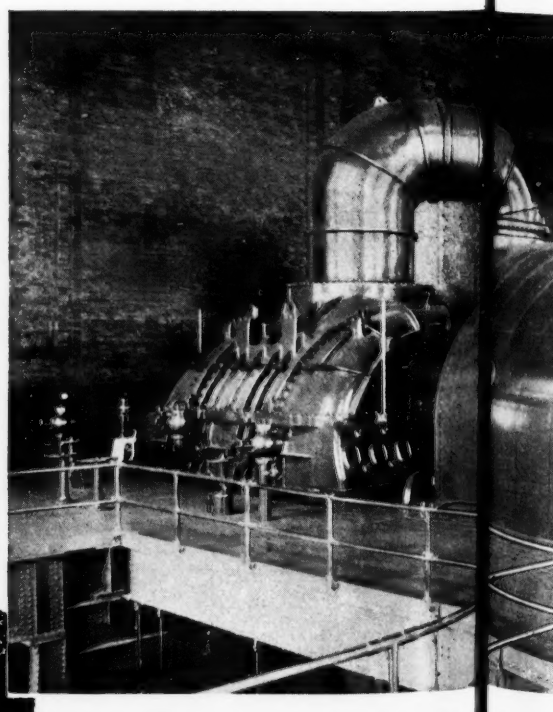


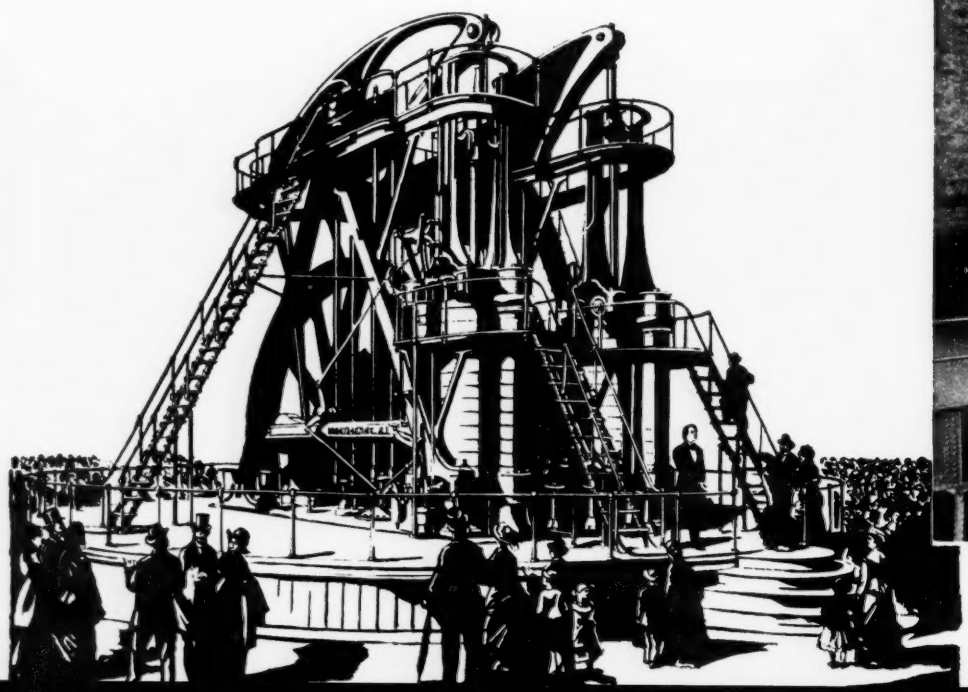
Fifty years of operating skill and mechanical genius are the symbols which mark the Golden Jubilee of the N.A.P.E.



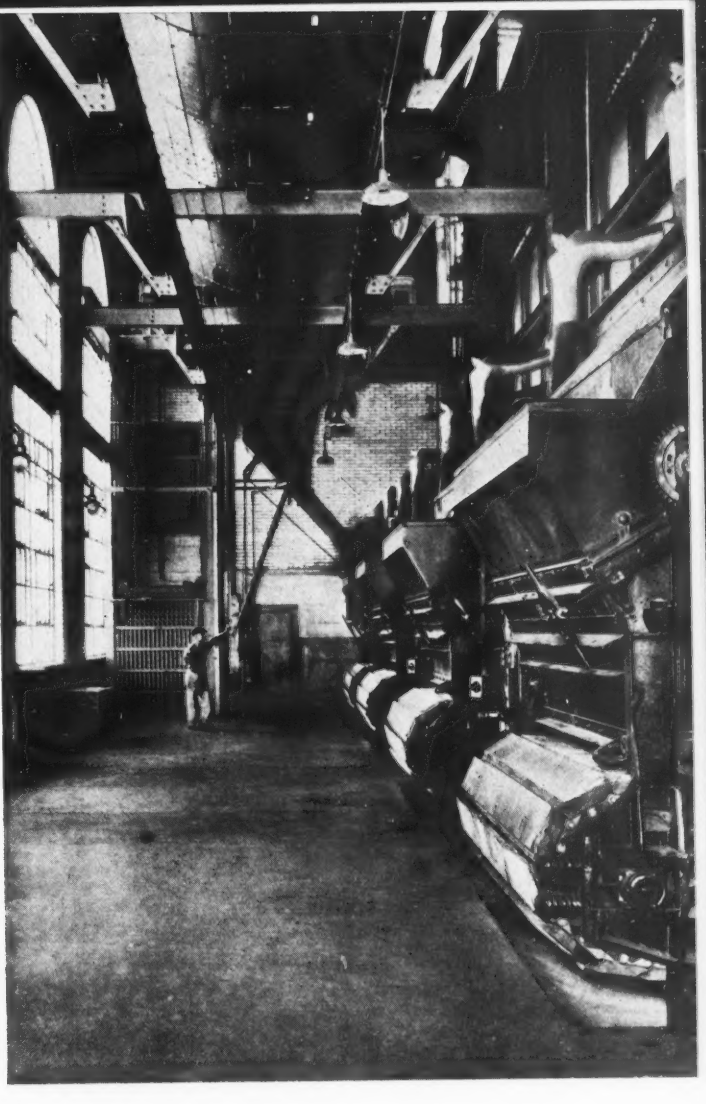
Contrast Herr Otto's internal combustion engine of five decades ago with this first of five 7,000-b.hp., double-acting, two-cycle, solid-injection diesel engines for the municipal generating station of Vernon, Calif. Each engine has eight cylinders of 24-in. bore and 36-in. stroke, is 56 ft. long and weighs 850,000 lb. Each will be connected to a 5,000-kw. generator

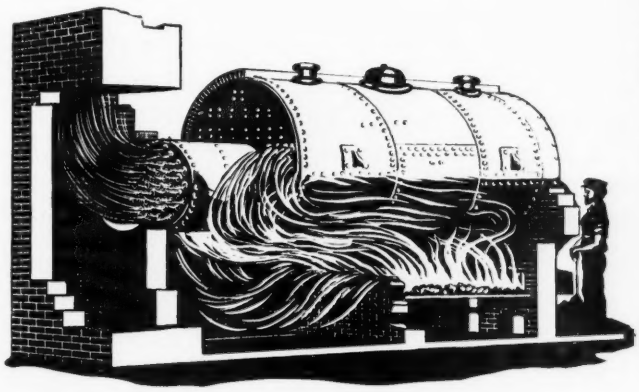
50 YEARS OF



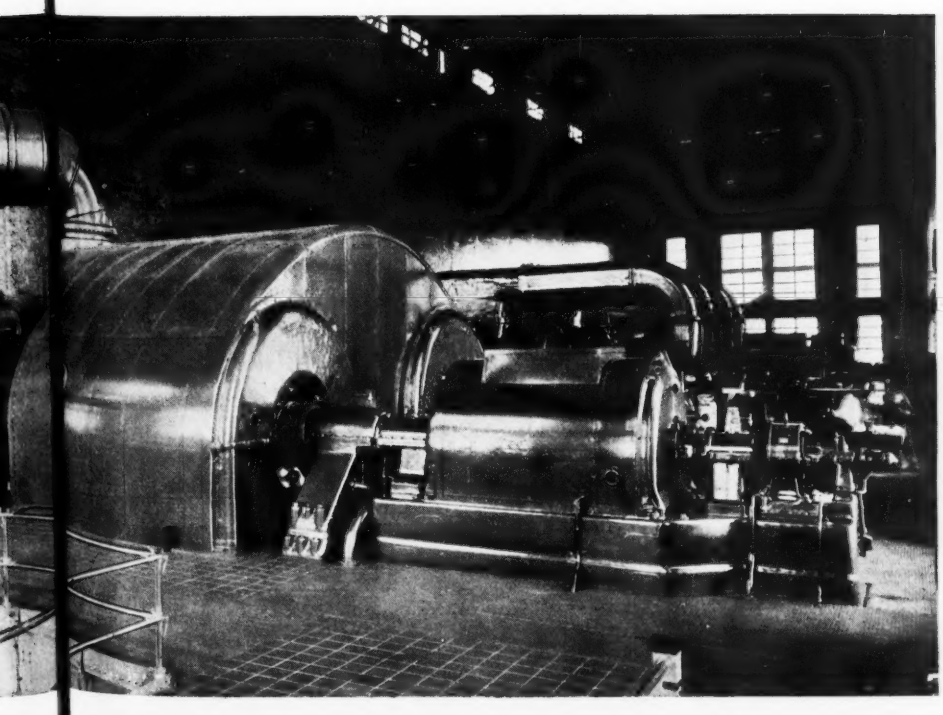


Back in 1882, boilers were hand-stoked by capped or plug-hatted heroes with full beards, rolled sleeves and bared chests. With stoker installations of today, the operator uses his head — while mechanical stokers replace brawn. Illustrated is the boiler room of the St. Louis Medical Center, typical of modern practice



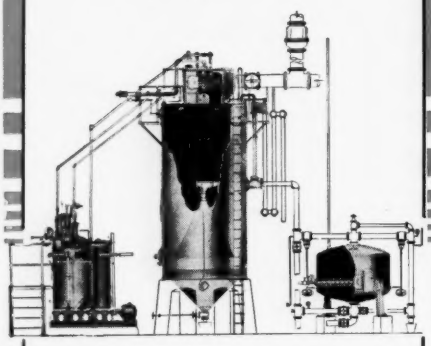


POWER PROGRESS



The Centennial Corliss was long the inspiration of power engineers. Its 2,500 hp. and weight of 1,214,000 lb. was a world wonder. Today, a single turbo-generator at Hell Gate Station can generate eighty-five times as much horsepower and weighs only twice as much. From 1,865 kw. to 160,000 or 208,000 (State Line Station) is the half-century record of progress

COCHRANE
HOT PROCESS SOFTENER

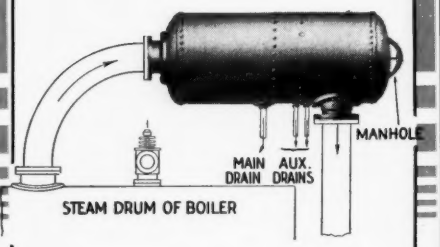


Conditions water for high pressure boilers

By modifying the water treatment according to the nature of the water supply, high pressure boilers are now operated satisfactorily on 100 per cent make up, without scale, corrosion or danger of embrittlement. The Cochrane Hot Process treatment utilizes phosphates according to the Hall patents to secure perfect softening while keeping the carbonate—sulphate ratio within the A.S.M.E. Boiler Code requirements to avoid embrittlement.

Ask for Bulletin L-689.

COCHRANE
STEAM PURIFIER

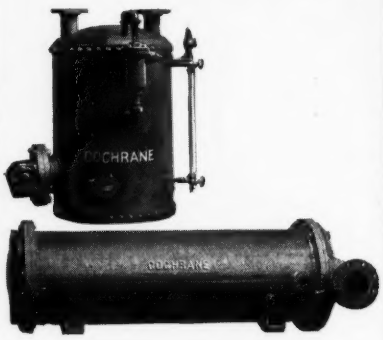


Insures dry, clean steam at all ratings

The Cochrane Steam Purifier delivers pure steam regardless of the wetness of the entering steam, the design of boiler, the method of feeding, or the concentration of the boiler water. Superheaters are protected from scale, and give maximum superheat. Turbines and valves are protected against erosion and deposits. Boilers can be driven harder and with more latitude in character of water.

Ask for Bulletin L-684.

COCHRANE
CONTINUOUS BOILER BLOW DOWN



Saves heat and water

The concentration of the boiler water is maintained constantly at the desired value by blowing off continuously a small stream, from which heat is recovered in the form of flashed steam and by means of heat exchangers. The resultant saving of heat and fuel pays for the equipment in two years or less. The operation of the boilers is more simple and regular and the steam produced is more uniform in quality than where the boilers are blown down intermittently. Continuous blow down, in combination with Cochrane water softening equipment, makes operation with 100 per cent make-up practicable and economical.

Ask for Bulletin L-683-A.

COCHRANE CORPORATION 17th & Clearfield Streets, **PHILADELPHIA, PA.**

Apparatus that one cannot afford to be without

EQUIPMENT which will return its cost within one or two years is profitable in poor times as well as good times.

A few degrees higher temperature of the feed water, representing fuel saved,

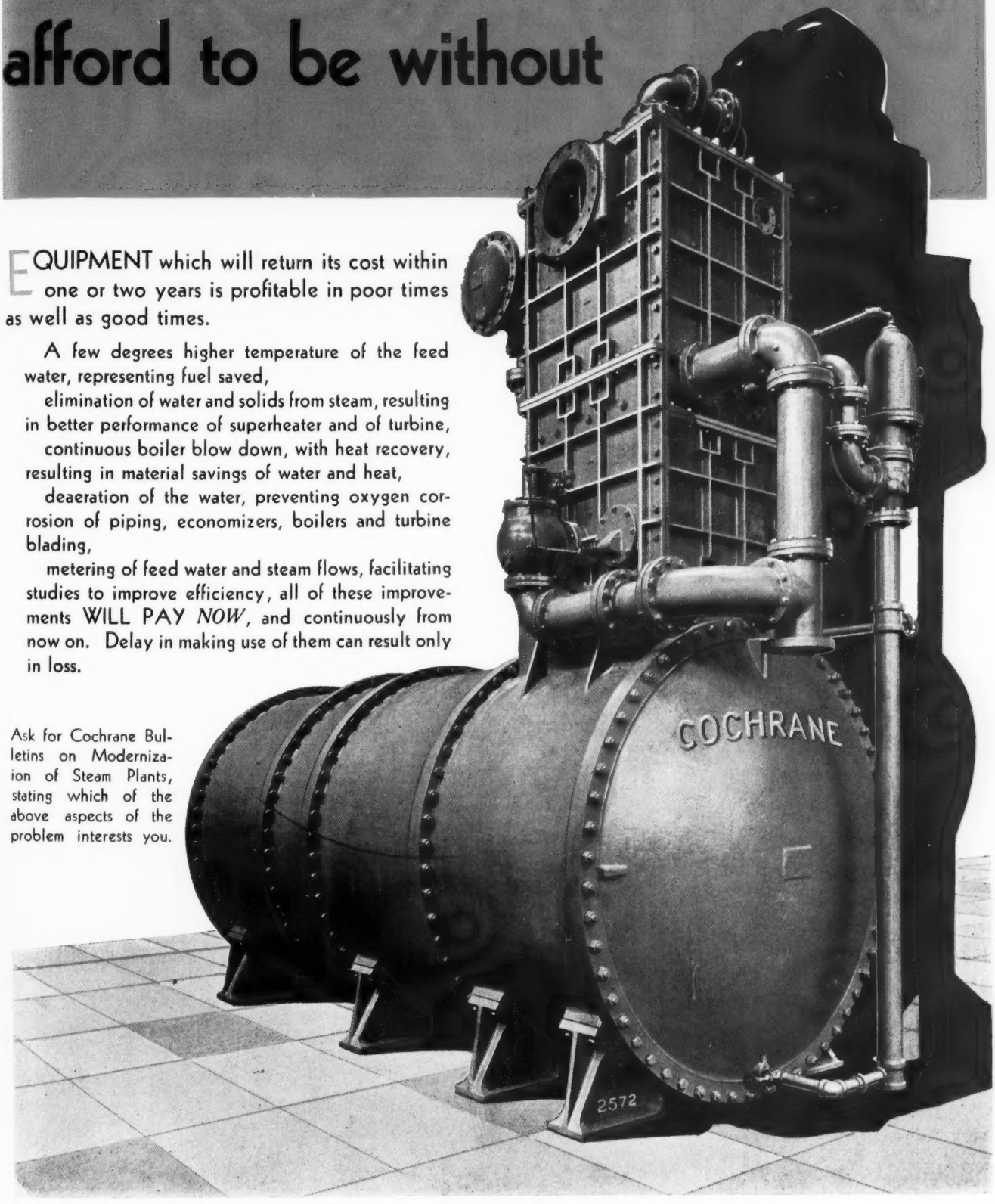
elimination of water and solids from steam, resulting in better performance of superheater and of turbine,

continuous boiler blow down, with heat recovery, resulting in material savings of water and heat,

deaeration of the water, preventing oxygen corrosion of piping, economizers, boilers and turbine blading,

metering of feed water and steam flows, facilitating studies to improve efficiency, all of these improvements WILL PAY *NOW*, and continuously from now on. Delay in making use of them can result only in loss.

Ask for Cochrane Bulletins on Modernization of Steam Plants, stating which of the above aspects of the problem interests you.



Combined Deaerating Heater, V-Notch Meter and Storage Tank

COCHRANE CORPORATION 17th & Clearfield Streets, **PHILADELPHIA, PA.**

POWER'S DATA SHEETS

NUMBER 2

COALS OF THE UNITED STATES

THE COAL analyses given are based on a report by M. R. Campbell presented at the World Conference on Bituminous Coal in 1926. Types of coal have been abreviated as follows: Anthracite, An.; Bituminous, B.; Coking, B.C.; Semi-Bituminous, Semi-B.; Sub- Bituminous, Sub- B.; High Rank, H.R.; Low Rank, L.R.

Location and Rank of Coal	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	Heat Value B.t.u.
ALABAMA						
Birmingham district, B. C.	2.4	25.9	66.8	4.9	1.5	14,490
Birmingham district, B.	1.7	31.3	60.8	6.2	1.5	14,290
Carbon Hill district, B.	4.7	31.8	53.3	10.2	1.3	12,600
Tuscaloosa district, B.	1.6	25.0	68.5	4.9	.5	14,700
Cahaba field, B.	3.1	35.0	55.8	6.1	.4	13,560
ARIZONA						
Black Mesa field, sub.-B.	9.9	32.6	46.9	10.6	1.1	10,800
ARKANSAS						
Coal Hill district, semi-B.	1.4	14.8	76.9	6.9	1.5	14,330
Paris district, semi-B.	2.8	14.7	73.4	9.1	2.8	13,770
Camden district, lignite.	39.4	26.5	24.4	9.7	.5	6,360
COLORADO						
Denver field, sub-B.	18.8	30.5	44.5	6.2	.3	9,650
Colorado Springs field, sub-B.	26.2	29.7	37.7	6.4	.3	8,350
Canon City field, B.	9.1	35.7	48.0	7.2	.9	11,700
Trinidad field, B. C.	2.1	32.6	52.5	12.8	.7	12,960
Crested Butte field, An.	3.0	2.9	86.6	7.5	.7	13,500
Crested Butte field, B.	5.6	37.6	47.6	9.2	.4	12,430
Grand Junction field, B.	7.6	33.6	52.9	5.9	.7	12,440
GEORGIA						
Manlo district, semi-B.	2.9	17.1	72.2	7.8	.7	14,200
ILLINOIS						
La Salle County, B.	13.9	37.3	38.5	10.3	3.4	10,990
Sangamon County, B.	14.3	37.2	40.3	8.2	4.4	11,010
Macoupin County, B.	13.3	37.1	40.7	8.9	4.1	11,160
Madison and St. Clair, B.	12.7	36.4	41.4	9.5	3.7	10,900
Franklin County, B.	9.2	33.8	48.6	8.4	.9	11,930
Williamson County, B.	8.8	29.9	53.8	7.5	1.1	12,220
Saline County, B.	6.0	32.4	54.3	7.3	1.7	12,790
INDIANA						
Vermilion County, B.	10.5	39.5	39.6	10.4	4.0	11,430
Clay County, B. block	15.4	32.6	46.1	5.9	2.0	11,680
Sullivan County, B.	13.6	35.0	44.6	6.8	1.1	11,550
Knox County, B.	10.6	38.1	43.0	8.3	3.7	11,750
IOWA						
Polk County, B.	14.4	37.8	36.8	11.0	5.9	10,640
Mahaska County, B.	14.6	36.3	40.5	8.6	2.9	11,000
Lucas County, B.	18.7	31.8	41.8	7.7	2.4	10,510
Appanoose County, B.	17.1	35.4	40.4	7.1	4.0	10,930
KANSAS						
Leavenworth County, B.	12.0	35.2	39.1	13.7	4.4	10,720
Crawford County, B.	4.9	33.5	52.5	9.1	5.0	12,940
Cherokee County, B.	5.1	32.6	53.4	8.9	4.3	12,930
EASTERN KENTUCKY						
Pike County, B.	2.8	36.2	56.7	4.3	1.4	14,180
Letcher County, B.	2.5	36.5	57.0	4.0	.6	14,150
Harlan County, B.	4.4	35.0	56.9	3.7	.7	13,920
Bell County, B.	2.8	37.8	56.3	3.1	1.0	14,240
Knox County, B.	4.2	36.4	53.3	6.1	.8	13,410
WESTERN KENTUCKY						
Daviess County, B.	11.8	36.8	42.0	9.4	3.3	11,150
Muhlenberg County, B.	8.8	36.2	46.4	8.6	3.6	11,900
Hopkins County, B.	8.5	38.0	46.4	7.1	3.5	12,340
Union County, B.	3.9	37.1	49.7	9.3	3.5	12,830
MARYLAND						
Georges Creek basin, semi-B.	2.3	16.3	70.6	10.8	.8	13,510
Upper Potomac basin, semi-B.	4.3	21.3	64.4	10.0	2.5	13,270
Lower Youghiogheny, B.	2.3	25.5	64.4	7.8	1.1	13,780
MICHIGAN						
Saginaw district, B.	1.9	31.5	49.8	6.8	1.2	11,780
MISSOURI						
Adair County, B.	15.4	34.8	38.8	11.0	3.6	10,460
Macon County, B.	13.8	34.7	41.8	9.7	3.3	10,960
Ray County, B.	15.8	32.8	41.5	9.9	3.0	10,620
Lafayette County, B.	12.3	34.4	42.0	11.3	4.6	11,000
Henry County, B.	10.6	37.2	40.7	11.5	3.6	11,250
MONTANA						
Glendive district, lignite.	34.6	35.3	22.9	7.2	1.1	7,090
Lewistown district, B.	8.0	26.6	56.1	9.3	4.4	11,510
Roundup district, sub-B.	13.4	32.4	47.6	6.6	.4	11,120
Bridger district, B.	9.8	27.6	46.2	16.4	.6	10,240
Bear Creek district, sub-B.	10.7	34.1	46.1	9.1	1.5	10,800
Red Lodge district, sub-B.	11.7	36.1	40.2	12.0	1.1	9,790
NEW MEXICO						
Raton field, B. C.	2.1	36.1	50.2	11.6	.6	12,970
Los Cerrillos field, An.	5.7	2.2	86.1	6.0	.7	13,270
Los Cerrillos field, B.	3.2	41.4	44.4	11.0	1.6	12,450
Gallup district, sub-B.	12.7	36.5	43.3	7.5	.7	11,230
NORTH CAROLINA						
Deep River field, B.	2.5	32.0	57.3	8.2	2.0	13,620
NORTH DAKOTA						
Williams County, lignite.	41.1	27.2	26.3	5.4	.7	6,490
Morton County, lignite.	38.5	27.6	26.6	7.3	1.3	6,700
Stark County, lignite.	40.5	26.3	27.0	6.2	.8	6,210
Adams County, lignite.	32.4	30.9	28.1	8.6	1.5	7,330
OHIO						
Tuscarawas County, B.	4.7	39.2	49.9	6.2	3.3	12,770
Jefferson County, B.	4.1	38.5	49.7	7.7	3.7	13,150
Belmont County, B.	3.9	43.1	43.9	9.1	4.4	12,840
Noble County, B.	3.6	41.5	44.4	10.5	4.9	12,510
Hocking County, B.	9.7	32.5	53.4	4.4	.5	12,250
Meigs County, B.	7.2	32.8	50.7	9.3	1.3	12,000
OKLAHOMA						
Okmulgee County, B.	7.5	32.9	51.0	8.6	1.5	12,410
Haskell County, semi-B.	2.7	21.1	69.9	6.3	.8	14,100
Le Flore County, semi-B.	2.5	19.1	71.7	6.7	.5	14,040
Pittsburg County, B.	3.6	33.4	58.0	5.0	.5	13,740
Coal County, B.	6.5	39.0	45.2	9.3	3.7	11,840
OREGON						
Coos Bay field, sub-B.	18.0	31.8	39.7	10.5	2.2	8,910
PENNSYLVANIA						
Anthracite region, An.	2.8	1.2	88.2	7.8	.9	13,300
Lykens Valley, semi-An.	1.1	9.6	79.5	9.8	.7	13,590
Sullivan County, semi-An.	3.4	9.3	75.6	11.7	.8	13,120
Tioga County, semi-B.	2.3	20.9	66.9	9.9	1.3	13,620
Elk County, B.	2.7	33.7	54.9	8.7	2.9	13,470
Center County, B.	3.5	23.7	61.6	11.2	2.7	13,060
Clearfield County, semi-B.	3.3	19.9	69.0	7.8	2.0	14,020
Indiana County, B.	1.0	26.1	63.8	9.1	2.7	13,950
Butler County, B.	4.6	33.0	54.4	8.0	1.3	13,200
Cambria County, semi-B. L. R.	2.0	21.2	70.9	5.9	1.2	14,510
Cambria County, B.	3.1	26.0	64.4	6.5	1.4	14,160
Westmoreland County, B. C.	2.7	30.4	57.8	9.1	1.3	13,610
Allegheny County, B.	3.7	34.0	56.8	5.5	1.4	13,870
Broadtop field, semi-B.	2.1	15.5	76.0	6.4	1.1	14,470
Somerset County, semi-B.H.R.	2.5	12.5	78.8	6.2	1.1	14,380
Fayette County, B. C.	2.8	30.0	59.8	7.4	1.2	13,990
Washington County, B.	1.4	34.6	57.8	6.2	.8	14,240
RHODE ISLAND						
Portsmouth district, super-An.	13.2	2.6	65.3	18.9	.3	9,310
SOUTH DAKOTA						
Harding County, lignite.	41.5	24.0	24.3	10.2	.6	5,650
TENNESSEE						
Claiborne and Campbell Cty. B.	3.6	37.3	55.5	3.6	1.1	13,980
Anderson County, B.	2.2	37.2	54.5	6.1	1.6	13,960
Roane and Rhea counties, B.C.	2.2	29.6	59.4	8.8	.5	13,620
TEXAS						
Houston County, lignite.	33.5	39.5	16.2	10.8	.6	7,140
Wood County, lignite.	28.9	35.9	27.3	7.9	.5	8,000
UTAH						
Uinta County, B.	8.6	36.1	47.2	8.1	1.4	11,580
Sunnyside, B. C.	4.0	38.0	51.3	6.7	1.2	13,120
Castlegate, B.	2.9	40.0	51.7	5.4	.3	13,350
VIRGINIA						
Tazewell County, semi-B.	3.8	15.5	77.8	2.9	0.6	14,860
Dickinson County, B.	3.0	32.4	58.4	6.2	1.6	14,030
Russell County, B.	2.8	34.9	56.5	5.8	.6	14,150
Wise County, B. C.	2.5	31.7	60.3	5.5	.5	14,250
Lee County, B.	3.4	34.4	58.8	3.4	.6	14,130
Pulaski County, semi-An.	2.1	10.2	68.7	19.0	1.0	12,110
Richmond Basin, B.	2.8	25.7	62.5	9.0	1.4	13,490
WASHINGTON						
Newcastle district, sub-B.	12.1	36.8	40.7	10.4	.3	10,410
Renton district, sub-B.	14.4	36.1	42.0	7.5	.6	10,560
Black Diamond district, B.	6.8	40.0	47.9	5.3	1.4	12,330
Carbon Hill district, B.	3.4	32.2	49.5	14.9	.5	12,250
Roslyn district, B.	4.7	36.0	46.8	12.5	.4	12,240
Cle Elum district, B.	5.0	36.1	46.8	12.1	.4	11,900
Centralia district, sub-B.	21.0	33.1	36.7	9.2	.4	8,910
WEST VIRGINIA						
Wheeling district, B.	4.1	36.6	53.3	6.0	2.1	13,400
Fairmont district, B.	2.9	34.5	56.9	5.7	.7	14,040
Clarksburg district, B.	2.8	38.5	53.1	5.6	2.4	14,110
Upper Potomac, semi-B.H.R.	1.1	17.2	73.8	7.9	1.1	14,490
New River dist., semi-B.H.R.	4.0	14.1	73.7	8.2	.8	13,850
Beckley dist., semi-B.H.R.	4.7	13.0	77.9	4.4	.8	14,340
Beckley dist., semi-B.L.R.	3.3	18.0	75.6	3.1	.8	14,660
Coalburg district, B.	3.4	35.2	53.1	8.3	.7	13,000
Logan district, B.	3.3	33.3	58.4	5.0	.7	14,050
Thacker district, B.H.R.	3.1	31.4	59.9	5.6	1.2	14,050
Iaeger district, semi-B.	2.0	19.9	70.4	7.7	.7	14,110
Pocahontas field, semi-B.L.R.	3.4	22.5	68.8	5.3	.5	14,370
Welch district, semi-B.H.R.	2.8	15.0	76.5	5.7	.9	14,330
WYOMING						
Sheridan district, sub-B.	22.6	32.5	40.4	4.5	.3	9,220
Bighorn Basin field, sub-B.	16.5	32.9	45.8	4.8	.6	10,750
Hanna Basin field, sub-B.	11.5	42.6	39.3	6.6	.4	10,890
Rock Springs field, B.	9.8	34.3	52.5	3.4	1.0	12,260
Kemmerer district, B.	5.7	37.7	51.3	5.3	1.4	12,580
Kemmerer district, sub-B.	20.6	36.3	40.5	2.6	.5	10,240

©Power

STARTING SYNCHRONOUS MOTORS ON PART OF STATOR WINDINGS

Synchronous motors built with two or more parallel stator windings are started by connecting one winding to full-line voltage. After the motor has been accelerated to a predetermined speed, the remaining windings are connected to the line

DURING starting the low power factor of a synchronous motor, due largely to the motor's magnetizing current, causes high starting kilovolt-amperes per unit of starting torque. Because of the usual comparatively large horsepowers of these motors, the method selected for starting them is of considerable concern if objectionable disturbances in the power system are to be avoided.

When the power system has sufficient capacity, these motors are usually started on full voltage. This is the simplest method and is generally preferred where conditions will permit its use. In many installations, however, full-voltage starting is not feasible because of undesirable effects on the power system's voltage and other objectionable features. In cases where reduction of starting kilovolt-amperes is necessary, reduced-voltage starting has been widely employed, using an auto-transformer, a reactor or a resistance to reduce the voltage on the motor.

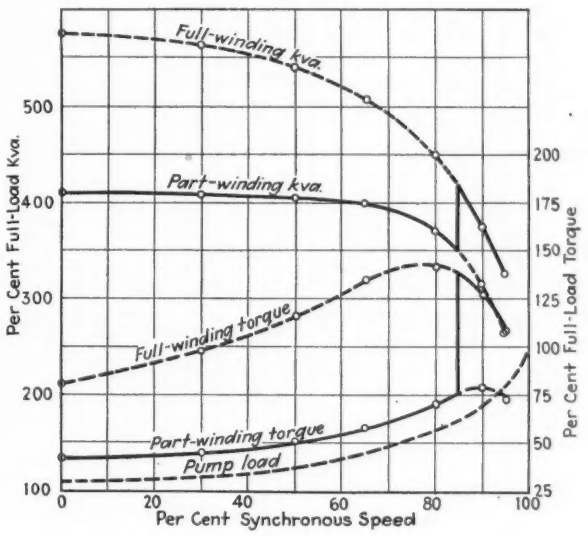
Part-winding starting, a newly developed means of starting synchronous motors, is now being used extensively by the Electric Machinery Manufacturing Co., which supplied the data and illustrations for the preparation of this article. With part-winding starting, the motor's stator winding is divided into two or more parallel circuits. One of these circuits is connected to full voltage for starting the motor from standstill. The remainder of the winding is connected to the line at a later time during the starting period.

Grouping of the Windings

When one of two suitably distributed stator circuits is connected to full line voltage, its impedance is considerably greater than that of the two windings in parallel and results in lower starting kilovolt-amperes and torque than with the full winding. The values of starting kilovolt-amperes and torque obtained depend to a considerable extent on the stator-winding's arrangement with respect to the magnetic circuits in the stator core.

There are two principal types of stator coil groupings for part-winding starting. In one of these, half of the coils in each phase belt are connected in each circuit. With this arrangement alternate-slot connections and split-phase-belt connections are used, and every pole is directly but only partially excited. Alternate-pole connections are also used where only poles of like polarity are excited, and those of unlike polarity become consequent poles. Fig. 1 shows the tested starting torque and starting kilovolt-amperes for a 600-hp. 1,800-r.p.m. motor, with the alternate-pole type of connection, designed to drive a centrifugal pump.

With the second general type of part-winding connections, groups of two or more adjacent poles in the



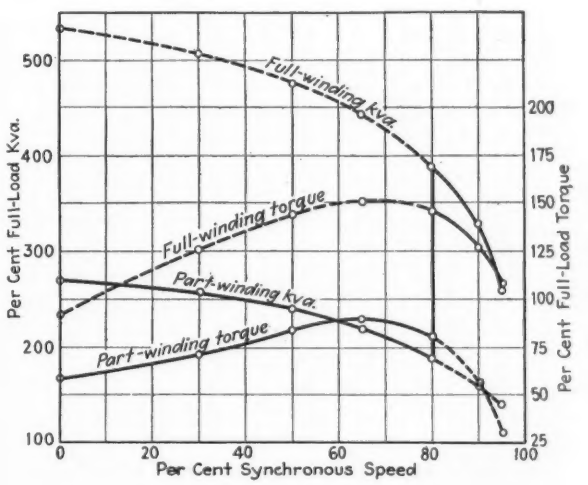


Fig. 1 (Top)—Speed-torque and kilovolt-ampere curves of a 600-hp., 1,800-r.p.m. synchronous motor driving a centrifugal pump. Fig. 2—Speed torque and kilovolt-ampere curves of a 500-hp., 514-r.p.m. synchronous motor geared to a reciprocating pump

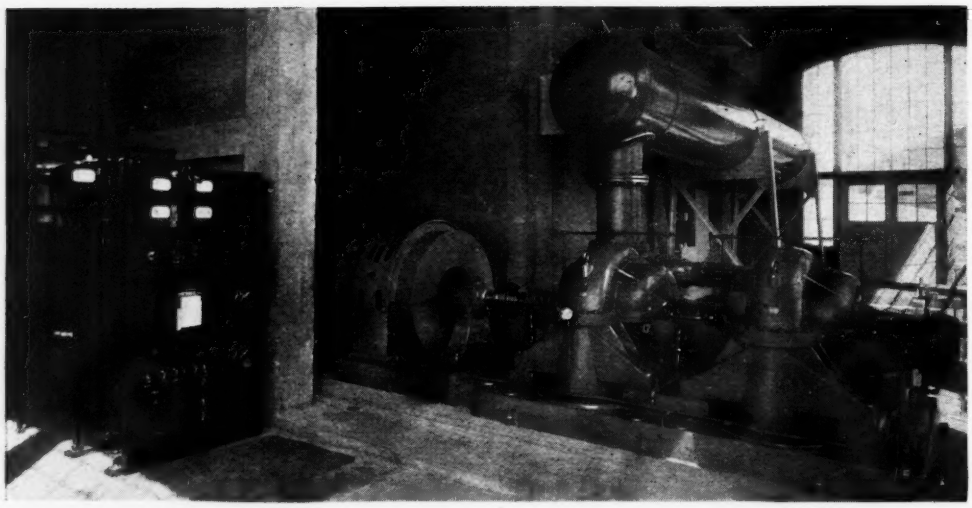


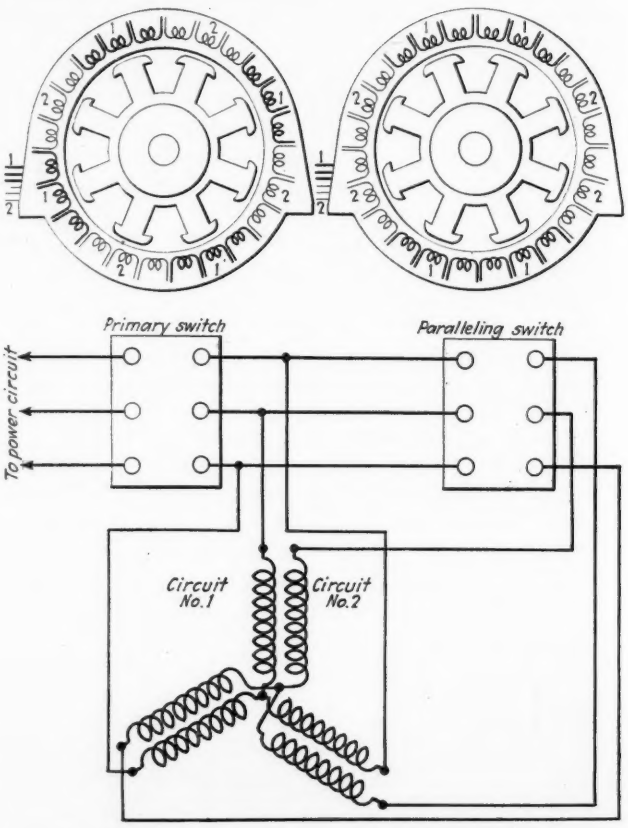
Fig. 3—A 1,250-hp., 1,200-r.p.m. part-winding synchronous motor driving a high-speed centrifugal pump

stator windings are connected in each circuit. Starting torque and kilovolt-ampere values for a 500-hp. motor with this type of connection and geared to a reciprocating pump are shown in Fig. 2. The starting torque per kilovolt-ampere is higher than for the type of connection used in Fig. 1.

Stator coils arranged for using alternate-poles for starting are shown diagrammatically in Fig. 4, and for alternate groups of two poles in Fig. 5. In both cases the groups marked 1 are energized when starting and those marked 2 are connected after the motor has accelerated to a predetermined speed.

Since synchronous motors can normally be designed and built with two or more parallel circuits per phase, the winding arrangement used to secure part-winding starting does not involve additional complications in construction, except to bring out three additional leads, in the case of a 3-phase motor, for each starting step.

The stator-coils are the only factor limiting motor sizes with part windings for starting. A two-circuit winding requires twice the number of turns per coil that would be used with a one-circuit connection. Additional circuits require an increase in the number of turns per coil. For this reason, the smaller size limit is dependent on the size of wire that may be used to wind a satisfactory stator coil. Operating characteristics of the synchronous motor, such as efficiency and power factor, will not be materially affected by the parallel-circuit construction used for part-winding starting.



Figs. 4 and 5 (Top)—Diagrams showing stator-coil groupings for alternate-pole and alternate two-pole connections. Fig. 6—Simplified control diagram for a two-circuit part-winding start synchronous motor

Part-Winding-Starting Control

Control for part-winding starting is simple, as indicated in the diagram, Fig. 6. When only two circuits are involved, as is usually the case, the control consists of a primary switch to connect the first section of the winding directly to the line. After a predetermined time a paralleling switch is closed that connects the second section to full voltage. The switches are so arranged that in case of overload or a short circuit the primary switch opens automatically and disconnects both of the motor windings from the line, after which the paralleling switch drops out.

Closing of the paralleling switch is controlled as is the application of field current to the motor, by frequency relays. The frequency of the voltage induced in the field-coil circuit of a synchronous motor by the current in the stator varies directly as the rotor slip, or inversely as the motor speed. At standstill the frequency of the induced voltage in the field coils is the same as that of the current in the stator winding. At synchronous speed the induced voltage and its frequency in the field coils is zero.

This change in frequency in the field coils is used to control the closing of the switches to accelerate the motor and apply excitation. Since the frequency in the field coils is a measure of the motor's speed, by designing the relays to function at a definite frequency, the paralleling switch can be closed when the motor has accelerated to a predetermined speed, and field excita-

tion is applied to the motor at the proper speed for synchronizing.

With part-winding starting there is less momentary disturbance on the line during starting and acceleration of the motor than with auto-transformer reduced-voltage starting. First, the magnetizing current of the auto-transformer is eliminated. Second, with an auto-transformer it is necessary to disconnect the motor from the line when transferring from reduced to full-voltage operation. When the motor is transferred from reduced to full voltage, the kilovolt-ampere inrush may be higher than the sustained full-voltage value. Transfer to full-winding operation with part-winding starting is accomplished by a change to the full-voltage kilovolt-ampere condition, corresponding to the motor speed at which the transfer is made. As a result the peak current inrush that occurs with auto-transformer starting is not experienced with part-winding starting.

Simpler starting equipment is required for part-winding starting than for reduced-voltage methods, because all means of reducing the voltage is eliminated. There are no auto-transformers, reactors or starting resistors to maintain; only one extra switch is required for controlling the second circuit. Where pull-in torque requirements are low, and it is desirable to keep the starting kilovolt-amperes as low as possible, the motor can be synchronized on the first step of winding and the full winding connected after synchronism.

Number of Starting Steps

Two steps are usually used for part-winding starting of synchronous motors. A larger number of steps for special conditions is practical for certain motors if starting limitations warrant. Actually, the number of circuits is limited by the size and voltage of the motor and by the number of poles.

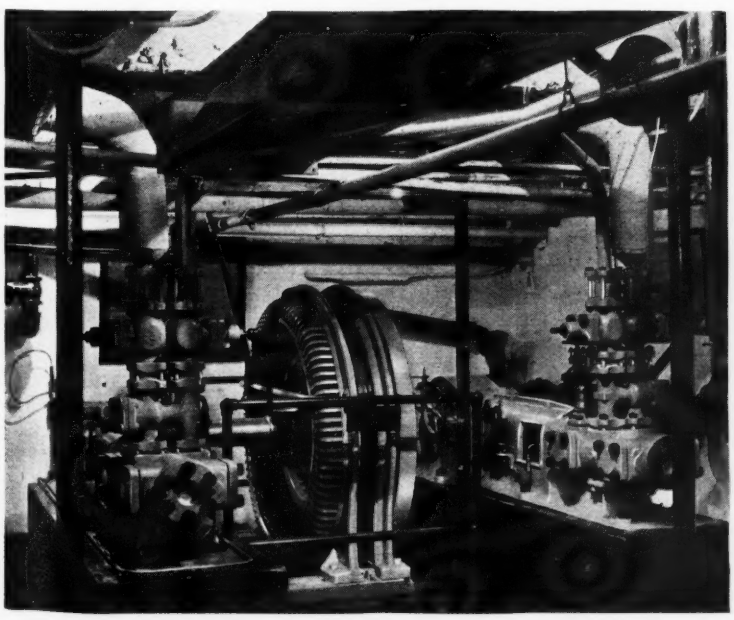
Part-winding starting has been used both with high-speed and low-speed motors. An important application for high-speed motors has been on centrifugal pumps. These high-speed motors normally take a high starting kilovolt-ampere inrush, which can be reduced by means of part-winding starting. The reduction of torque by use of one of the circuits in starting is not detrimental, since the breakaway torque required by a centrifugal pump is ordinarily low. As the pump comes up to speed, the torque required increases rapidly, but at some point in the speed curve, such as 80 to 90 per cent full speed, the second winding is switched in providing necessary torque to pull the load into synchronism. Part-winding starting is also suitable for drives such as fans, blowers, compressors, synchronous-motor generator sets, pulp grinders and others.

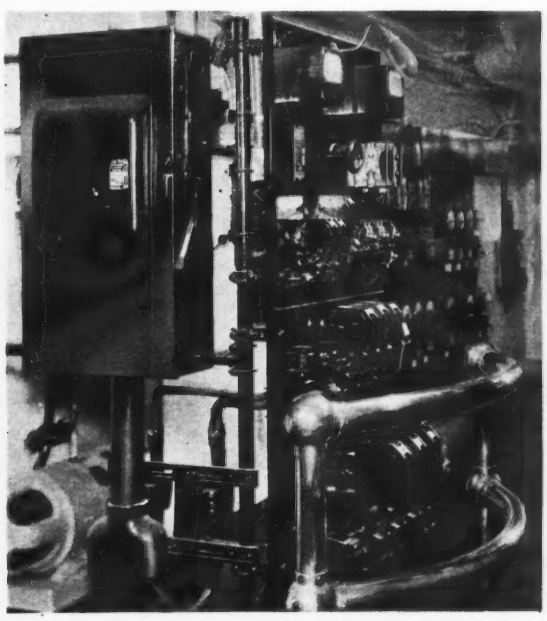
Increment starting is often desirable and sometimes essential where the motor is connected to a regulated feeder. Fig. 7 shows a 175-hp. 164-r.p.m. synchronous motor driving a two-cylinder double-acting, horizontal, single-stage CO_2 compressor. The motor uses two-circuit part-winding starting to keep the starting current within limits satisfactory to the utility supplying the power. The motor's control is shown in Fig. 8.

In other applications of synchronous motors driving CO_2 compressors three-step part winding has been used. One of the installations consists of a 225-hp. 360-r.p.m. synchronous motor driving a two-cylinder, vertical, single-acting compressor. The starting equipment is similar to the two-step installation, except that an additional contactor is provided for the third step of starting, together with the proper field-response relay to actuate the contactor at the proper speed. The total starting period with this installation is about six seconds.

Fig. 3 is the photo of a 1,250-hp., 1,200-r.p.m. synchronous motor driving a high-head centrifugal pump at the East Bay Municipal Utilities District, San Francisco, Calif. The control for this motor uses two-circuit part-winding starting. Another illustration of part-winding starting is that used on a 1,250-hp. 90 per cent power factor, 225-r.p.m. motor. The motor stator is wound with four parallel circuits, and each circuit is connected to the line separately with a definite time interval between steps. Incremental connection of this large motor to the line made possible starting it satisfactorily on a relatively small power system.

Figs. 7 and 8—A 175-hp., 164-r.p.m. two-circuit part-winding synchronous motor and controller for CO_2 compressor operation





In simple language, Mr. Ryan outlines the operation of zeolite and hot-process lime-soda softeners, pointing out the advantages and limitations of each.

THE ABC OF BOILER FEED-WATER SOFTENING

• LIME-SODA • • ZEOLITE •

By WILLIAM J. RYAN
Mechanical Engineer, Water Service Laboratories

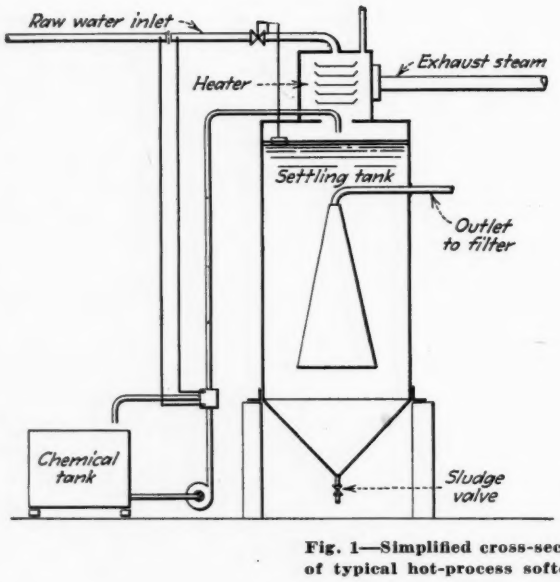


Fig. 1—Simplified cross-section of typical hot-process softener

TWO of the most generally used systems of external treatment are the hot-process lime and soda-ash softener, and the zeolite softener. It often happens that the engineer must decide on the purchase of one or the other, and he finds the choice difficult. An effort wil lbe made here to contrast them in such a way that the outstanding characteristics of each can be understood by one who has not made a study of this particular subject.

The principles of operation of these softeners have been presented so often that only a brief description will be given here to refresh the reader's memory. Fig. 1 shows diagramatically a typical hot-process lime and soda-ash softener. The hard water first enters the heater mounted on top of the reaction tank, where it is heated to 212 deg. F., or thereabouts by means of exhaust steam supplemented by live steam if necessary. The water then flows into the reaction tank where it meets the stream of chemical solution of lime and soda-ash, and possibly other chemicals, if required.

Means are provided for proportioning the flow of chemical solution to that of hard water. In the plant shown in Fig. 1, this is accomplished by feeding the chemical solution through a proportioning device actuated by the pressure drop across an orifice in the hard-water line. The settling tank holds about one hour's supply and the hard water is admitted by means of a float valve.

The insoluble calcium carbonate and magnesium hydroxide, formed by the reaction of the chemicals with some of the hardness in the water, settle into the bottom of the tank while the softened water passes upwardly into the cone-shaped collector and flows out of the tank and through a filter and thence to service.

Zeolite softeners depend on an entirely different principle. Fig. 2 shows diagramatically a zeolite softener in its simplest form. The hard water is passed through a tank containing zeolite and is softened by contact with it through the property of base exchange whereby the sodium in the zeolite replaces the calcium and magnesium in the water.

The water can flow in either an upward or downward direction. The softener shown in Fig. 2 is designed for downward flow. By means of valves the flow can be reversed occasionally for a few minutes to loosen the bed of mineral and remove any dirt that may have deposited.

Whenever the softening capacity of the zeolite is exhausted, it is replenished by passing through it a solution of common salt, the sodium of which replaces the calcium and magnesium accumulations in the zeolite and renders it ready to soften another batch of hard water.

Hardness of Treated Water

The hot-process softener will give an effluent with a hardness of about 1.5 gr. per gallon, or about 25 p.p.m. (parts per million). The hardness will vary according to the care exercised, and within certain limits it will go down or up according to the greater or lesser excess of chemicals used in the treatment.

With a zeolite softener the hardness of the water can be reduced to an average of about 2 to 10 p.p.m. Under the best conditions it will be practically zero, but the average water produced by the average softener will probably contain a small amount of hardness. If the hardness in the raw water is high, say over 20 gr. per gal., or if it has a high content of sodium salts, the hardness of the softened water will be higher than 10 p.p.m. and may run as high as 25 p.p.m., or even higher, in some cases.

The hot-process softener will usually reduce the amount of dissolved solids, as the treatment will precipitate all but about 1 to 2 gr. per gal. of the carbonate hardness. For example, suppose a certain water contains 6 gr. per gal. of carbonate hardness, 2 gr. per gal. of non-carbonate hardness and 2 gr. per gal. of sodium salts, making a total of 10 gr. of dissolved solids per gallon. After adequate treatment in a hot process softener the carbonate hardness will be reduced to about 1.5 gr. per gal. by precipitation of calcium carbonate, thus decreasing the amount of dissolved solids by 4.5 gr. per gal.

However, in order to remove the non-carbonate hardness by changing it to sodium salts, an "excess" of soda-ash, amounting to about 1.5 gr. per gal. must be used. This remains in solution in the treated water, thereby tending to increase the dissolved solids. The changing of the non-carbonate hardness into sodium salts also increases the weight of the dissolved solids. These increases partly off-set the reduction caused by the precipitation of carbonate hardness, so that with the above described water there is a net reduction of a little less than 3 gr. per gal.

As a general rule, to estimate the reduction in dissolved solids that may be accomplished by hot process, subtract three from the carbonate hardness (expressed as gr. per gal. of $CaCO_3$) and the remainder will give the approximate net decrease in grains per gallon that may be expected. It is evident from this that, when the raw water is high in carbonate hardness, a correspondingly large decrease in dissolved solids may be accomplished. But if the raw water contains less than 3 gr. per gal. of carbonate hardness, hot-process treatment may cause a slight increase in the dissolved solids rather than a decrease.

A zeolite softener will cause an increase of dissolved solids, due to the conversion of calcium and magnesium salts into sodium salts. This increase is comparatively small, being very roughly about 2 to 8 per cent, depending on the composition of the water.

The Sulphate-Carbonate Ratio

As a precaution against embrittlement and its very serious consequences, it is generally held that the boiler water should contain sulphates in excess of the hydroxide present. An alternative requirement is that there be maintained a certain concentration of a substance believed to prevent embrittlement, such as sodium phosphate. Certain definite ratios of salts have been recommended for different pressures.

To maintain the required ratio in the boiler, a certain ratio must be maintained in the make-up water. This is true because the concentration of salts dissolved in the boiler water will be in proportion to the amounts in the make-up (ignoring the possible effects of condenser leakage and scale deposition). To make sure that the desired condition is maintained in the boiler, the blow-down water must be analyzed frequently by the plant chemist or by a competent laboratory, and the treatment regulated accordingly.

The water from a hot-process softener may or may not conform to the desired sulphate-carbonate ratio. As explained above, the treated water will contain some sodium alkalinity, because an excess of soda-ash is required in the treatment. The amount of sulphate will be the same as in the raw water. If the sulphates are not sufficient to give the desired sulphate-carbonate ratio, the hot lime and soda-ash treatment is supplemented by one of the following:

1. Add sodium sulphate to the water
2. Treat with sulphuric acid (ahead of the hot lime and soda-ash treatment).
3. Maintain a certain concentration of PO_4 (phosphate) in the boiler water by adding sodium phosphate to the make-up water.

The first method obviously permits any desired ratio to be maintained. It also increases the amount of dissolved solids and the cost of treatment.

The Effect of Sulphuric Acid

The use of sulphuric acid ahead of the hot lime and soda-ash reduces the alkalinity and increases the sulphates according to the following equation:

$$H_2SO_4 + Ca(HCO_3)_2 \longrightarrow CaSO_4 + 2H_2O + 2CO_2$$

The more acid used the greater will be the ratio of sulphate to carbonate in the water. It should be noted that the use of acid decreases the carbonate hardness and increases the sulphate hardness. This will increase the amount of soda-ash and decrease the amount of lime required, with the further result of increasing the cost of treatment (in addition to the cost of the acid itself) because soda-ash is more costly than lime. This particular difficulty could be avoided by adding the acid *after* the hot-process treatment, but such an arrangement is undesirable for various reasons.

The zeolite softener water is not likely to have the desired sulphate-carbonate ratio. This is because most natural waters contain more bicarbonates than sulphates and the zeolite treatment does not reduce the alkalinity but simply changes all salts into sodium salts. Therefore, the zeolite softened water will contain corresponding amounts of bicarbonates and sulphates. And so, as a precaution against embrittlement, the zeolite treatment also is often supplemented by sulphuric-acid treatment or the addition of sodium sulphate or phosphate. In the case of a zeolite and sulphuric acid combination treatment, the acid can come ahead of the zeolite or vice versa.

The hot-process treatment is followed by filtration to remove any suspended calcium carbonate or dirt that may not settle out in the reaction tank.

A zeolite softening plant is preceded by filters if there are any considerable amounts of suspended impurities in the raw water.

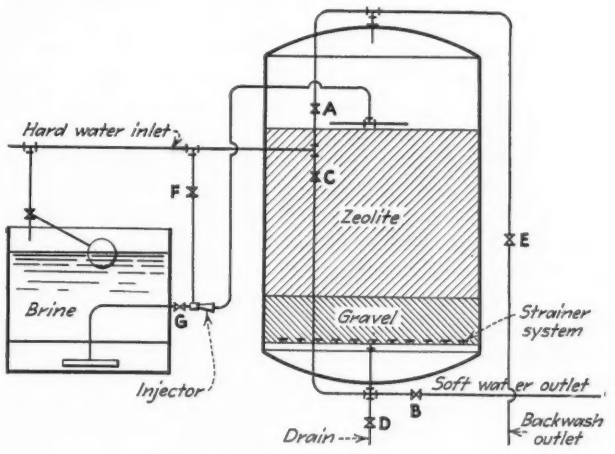


Fig. 2—Typical zeolite softener

To soften, open A and B. Close C, D and E.
To backwash, open C and E. Close A, B and D.
To inject brine, open F, G and D. Close A, B, C and E.
To rinse out brine, open A & D. Close B, C, E, F and G.

For comparatively small installations, such as would be required in industrial power plants, there will usually not be much difference in the cost of hot process and zeolite softeners. However, for large quantities of water high in carbonate hardness, the cost of a zeolite plant may be high unless the zeolite is preceded by a lime treatment to knock down the carbonate hardness.

There are no figures that are generally applicable to the cost of chemicals. The cost of operating a zeolite plant will depend on the price of salt in the particular locality. With a hot-process softener the cost will depend on the prices of lime and soda-ash and the amounts of each that will be required.

In addition, in either case, there may be the cost of acid, or tri-sodium phosphate, etc., as explained above. When the average analysis of the water has been determined by taking samples over a period of time, the cost of treatment with each system can be accurately estimated by a chemist who is familiar with the subject.

Occasionally a water is encountered whose analysis is such that there is no question as to what kind of treatment to use. But usually the various possible treatments must be carefully compared from the standpoint of chemical results obtainable and cost of treatment. It is very unwise to select a certain type of softener merely because similar equipment has given good results at another plant.

Diesel Ran On 3 Cylinders

By CHARLES A. TRIMMER

ON PAGE 926 of the June 21 number of *Power* appears an article by H. W. Stalnaker regarding the operation of a 4-cylinder diesel engine with one piston removed. In support of the fact that at least some types of diesel engines may be so operated, may I add to the record an experience had with one of the engines in the municipal electric plant at Madison, South Dakota.

At 7:10 p.m. on October 10, 1925, a piston "froze" in No. 3 engine (a 365-hp., 4-cylinder, 4-cycle, air-injection unit).

As the engine could not be spared without a serious curtailment of service to consumers over the peak period, the defective piston was removed, the oil hole in the shaft was plugged, the fuel and lubricating lines to this cylinder were disconnected, the cylinder head replaced and the engine operated on three cylinders over the peak period each evening. The engine was so operated for six days before a new liner and piston were obtained from the factory and installed. The daily operating periods varied from 4 hours and 20 minutes to 8 hours and 40 minutes, the total time operated on 3 cylinders being 32 hours and 20 minutes.

The unit was operated in parallel with other engines of the same type, but of smaller size, and its operation was entirely satisfactory, close attention being required to note the slight variation in the pulsation or firing of the cylinders.

With an average load of 106 kw. for the full period of 3-cylinder operation the fuel consumption per kilowatt-hour was 0.72 lb. The engine is a Busch-Sulzer 4 cylinder type B-90, installed in August 1915. It had been in daily service slightly more than 10 years at the time the above incident occurred and was operating on the original cylinder liners. The remaining three liners were not replaced until 1927.

UNLOADING C

By LEON BUEHLER JR.

Frick Company

IT IS well known that a much greater torque is required to start a machine from rest than to keep it running after it has come up to speed. Mechanics teaches us that force equals mass times acceleration, from which follows directly that a certain force must be applied to set the heavy flywheel and other moving parts in motion. Furthermore, bearings at rest have become relatively dry, and until proper lubrication has been established the frictional losses will be high.

These starting conditions cannot be eliminated, but the starting torque can in many cases be kept quite small by eliminating the working load of the machine until it has come up to speed. This can be done quite easily with compressors. With certain kinds of driving motors it is necessary or at least most advisable in order to reduce the first cost of the motor.

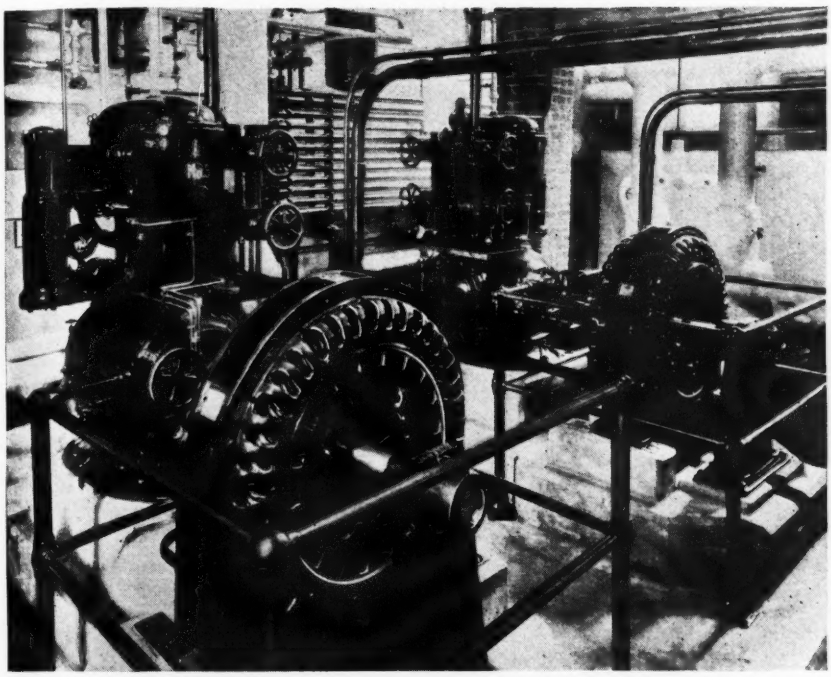
Electric motors in the smaller sizes can usually be purchased at slight additional cost with sufficient starting torque to obviate the need of unloading the compressor. This is fortunate, for it eliminates cost and complications that would be prohibitive on small machines. Large electric motors do not have sufficient starting torque, or can only be so built at high cost and a sacrifice of other characteristics. Oil engines started by compressed air or smaller internal combustion engines cranked by hand are obviously not suited to starting heavy loads.

There are two general methods of reducing the starting load: by disconnecting the compressor from the driving motor through a clutch or by reducing the compression ratio nearly to zero. Either method may be manually or automatically applied.

The clutch is most effective, as the starting load of the compressor, including inertia and frictional effects as well as the functional load, is gradually applied after the motor has come up to speed. Magnetic clutches are employed for automatic operation. They may be controlled by pushbutton, by the motor control, such as the field switch on a synchronous motor, or by any governing device that acts when the motor has come up to speed. The cost of these clutches has been higher than other methods of unloading and has prevented their more widespread use for this service.

There are several centrifugal clutches which are thrown into engagement at a certain speed. Some of these clutches will bring the load up to speed in stages. The clutch will engage for an instant, bringing the load into motion. As load is thrown on, the motor slows down and the clutch disengages. This

COMPRESSORS FOR EASY STARTING



The automatic by-pass valve is at the left side of the compressor

allows the motor to gain speed, and the clutch takes hold again. This is repeated until the load has been brought up to speed. Such clutches are in themselves automatic, requiring no outside power or control. To my knowledge they are built only in small sizes.

Reducing the compression ratio is the method almost universally employed. With an air compressor all that is necessary is to discharge to the atmosphere. In refrigeration systems this cannot be done, as the refrigerant must not be wasted—to say nothing of the danger of discharging noxious fumes to the air. Here the discharge is put in communication with the suction. If there are other compressors on the line, it is first necessary to shut off the main discharge line from the machine being started. This requires the manipulation of a number of valves. There are many variations of this design with which all larger compressors are equipped. Where machines must be frequently started the unloading becomes quite laborious, and automatic starting is impossible with this style of bypass.

By providing a bypass connection between the discharge and suction, controlled with a power-operated valve, starting is made automatic. In addition it is necessary to provide a check valve in the discharge between the bypass and the main line. The power valve can be actuated by a magnet, electric motor or hydraulic cylinder—in fact from any source of power desired.

The illustration shows a plunger actuated by oil pressure from a small motor-driven pump. In this design the starting switch operates the pump motor that opens the valve. When the valve is fully open the compressor motor automatically starts, and when the compressor is up to speed the pump motor is stopped. This allows the oil to leak back and the valve to close, which gradually throws the load on. The compressor can in this way be started simply by pressing a button, or any desired pilot switch may be employed. For instance a thermostat, a pressure switch or a time switch may be used.

While the demand for automatic control of ice and refrigerating plants is increasing, automatic unloading is by no means limited to this field. Engineers, like everyone else, are just a little lazy and are glad to be relieved of manipulating bypass valves. To the owner this may seem a luxury, and for most operating conditions that viewpoint is quite understandable. Thunderstorms do occur in the hottest weather when the refrigerating equipment is strained to the utmost holding temperatures or producing the last cake of ice of which it is capable. Such storms sometime cause power shutdowns, perhaps only a flicker of lights, yet enough to stop a synchronous motor.

It takes five minutes to start a compressor, considerably longer for the larger ones where the valves are slow moving. Under those conditions it is all the engineer can do to keep one compressor going without too much loss of time. If he has three, four, six or eight machines a storm often virtually means complete shutdown for an hour or two, when actually the lights have barely more than flickered in that period three or four times. The automatic unloader will immediately start all machines; in many cases they will only slow down a bit and then come right back up to speed.

It is by no means suggested that the additional expense of this equipment is justified in all cases. Where automatic control is desired automatic unloading is essential on larger machines. Where shutdowns during storms will interrupt costly processes or endanger valuable goods in storage, it will soon pay for itself.

Addition to Penn Sugar Equipment

ATTENTION has been called to the omission of "Televisors," made by the Schutte Koerting Company, from the list of equipment appended to the Pennsylvania Sugar article in the August number. This equipment gives distant readings of water level by an electrically operated indicator. Water level is shown by the junction of red and blue illuminated fields in the indicating instrument.

BACK-PRESSURE TURBINES GIVE HIGH THERMAL EFFICIENCIES

By M. F. KNOY

SINCE it has taken power engineers and equipment manufacturers several decades to obtain a thermal efficiency of around 30 per cent for the modern steam-driven central station, it is no wonder that the prospect of obtaining a thermal efficiency of 80 per cent or better should prove attractive. Where the conditions are right for its application, the back-pressure turbine is a surprisingly efficient heat engine.

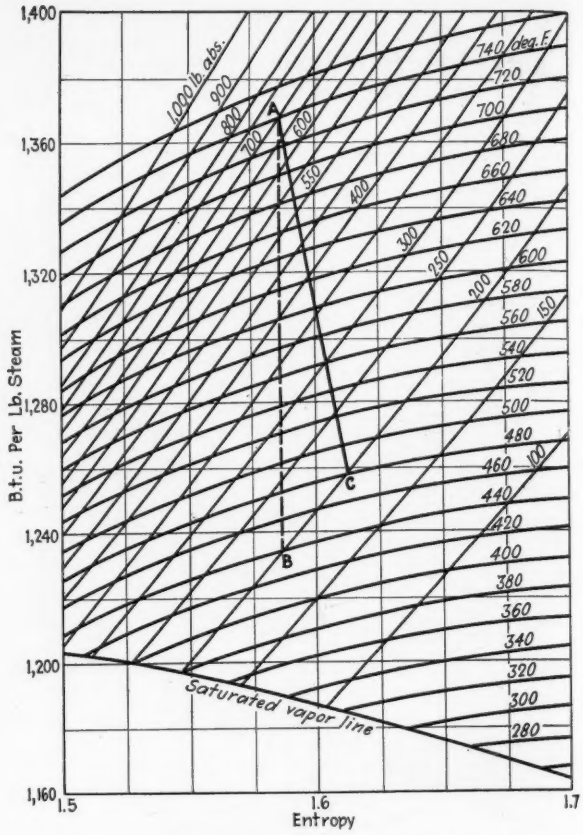
It is well-known that the total heat of low-pressure steam is nearly as great as that of high-pressure steam. This total heat consists largely of the latent heat of evaporation. Hence, if the steam is utilized in such a manner as will permit it to condense and give up its latent heat where it can be used to full advantage, then low-pressure steam is practically as valuable as high-pressure steam, pound for pound.

On the other hand high-pressure steam requires but little more fuel for its generation. It can be passed through a back-pressure turbine or engine and thus made to generate considerable power on its way to a heating system or process work. Practically all of the heat given up by the steam in the turbine can be converted into useful work.

Take for example a plant requiring process steam at, say, 200 lb. absolute pressure and preferably some superheat to facilitate distribution in the plant. If it is generated at 700 lb. absolute and 740 deg., the line *AB* in the chart would represent its adiabatic expansion to 200 lb. absolute. If used in a turbine having a Rankine efficiency of 82 per cent, the line *AC* would represent its expansion. From the chart, it is seen that the adiabatic expansion of the steam causes it to give up 134 B.t.u. per pound in the process, but that the actual expansion in the turbine causes the steam to lose only 110 B.t.u. This corresponds to the Rankine efficiency of 82 per cent, which is perhaps a little high.

But right here is evident the redeeming feature of the back-pressure turbine. All of the heat not converted into work in the turbine or lost by radiation remains in the steam. Thus, the turbine in this case will extract 110 B.t.u. per lb. from the steam and convert practically all of it into useful work. Allowing 1 per cent for radiation losses from the turbine housing and 1 per cent for bearing friction, 98 per cent of the heat given up in the turbine is converted into useful work.

If the turbine is used to drive an alternator with an efficiency of, say, 95 per cent, then the over-all thermal efficiency of turbine and generator will be approximately



Heat-entropy diagram showing adiabatic and actual expansion of steam in a turbine

93 per cent. The unit will, under these conditions, deliver a kilowatt-hour to the switchboard for 3,670 B.t.u. given up by the steam in the turbine.

This does not mean, however, that such a plant can deliver a kilowatt-hour for each 3,670 B.t.u. in the fuel chargeable to the power plant, for all of the heat in the fuel cannot be converted into steam. There are certain unavoidable losses in the boiler room, such as radiation, unburned combustible and flue gas, and the by-product power should be charged with a fair share of these losses. In the case under consideration only about 11 per cent more fuel will be required to generate the steam at the higher temperature and pressure assumed. This would not increase boiler radiation loss appreciably, and for this reason none of this loss should be charged to the power plant. But the flue gas and unburned combustible losses on the extra fuel burned will be as great in proportion as on the fuel that would have been used for generating low-pressure steam. These losses may vary from above 25 per cent to less than 15 per cent, depending upon the nature of the fuel, percentage of excess air and upon final flue gas temperatures. Assuming in this case a stack loss of 15 per cent, then for each 3,670 B.t.u. delivered to the turbine, approximately 4,317 B.t.u. must be supplied in the fuel.

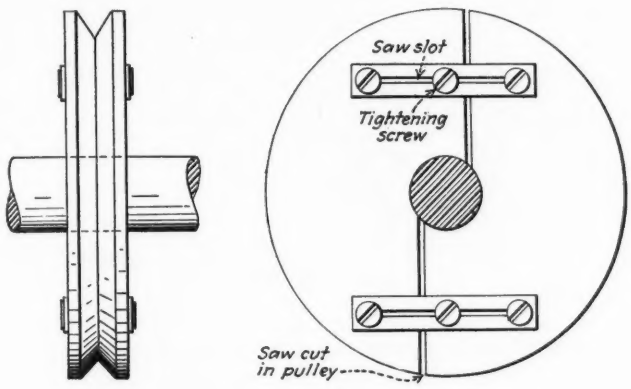
Expressed in another way, the over-all efficiency of the turbine and generator is 93 per cent and the increment boiler efficiency 85 per cent. The thermal efficiency of the back-pressure power plant will then be 0.85 x 0.93 = 79 per cent. Thus, while the back-pressure turbine is far from being a perfect heat engine, its thermal efficiency is so far above that of condensing equipment that the power engineer cannot afford to overlook any opportunity for its application.

PRACTICAL AIDS TO OPERATION

How a Split Pulley Was Tightened to Its Shaft

RECENTLY I had to make a grooved pulley, 10 in. in diameter, and place it on a shaft already crowded with pulleys. A split pulley was necessary, but how to tighten a thin wooden pulley of this diameter in a neat, effective manner was a problem. The method devised for doing this may be of interest, as I believe it to be new.

I made four sheet-steel straps, drilled them together, three holes in each, all countersunk. Next, a saw cut was made from the center hole to each outside one. The



pulley was split as shown in the diagram so that two screw holes could be placed on one side and one on the other. The center screw holes in the pulley were countersunk to facilitate tightening it on the shaft. With the pulley held tightly on the shaft, the four straps were fastened in place with a screw in each end. After this, I had merely to tighten the center screws to secure the pulley on the shaft.

Tightening the center screws spreads the straps apart in the middle, tends to shorten them and pulls the two halves of the pulley more tightly on the shaft. I was surprised at the small amount of tightening of the screws necessary to secure the pulley firmly to the shaft.

Hamilton, Ont. W. H. MOORE.

Lubricating Ammonia Compressor at Slow Speeds

IT HAS long been acceptable practice in the refrigeration field to vary the speed of an ammonia compressor within certain limits in order to obtain a desired refrigeration capacity. On several occasions I have seen the speed of a compressor lowered slightly when it was found that the compressor was furnishing more capacity than was needed. This practice under normal operating conditions, gives better efficiency than would be obtained by operating the machine intermittently and with a lower suction head on the evaporator. The slower speed permits a higher suction pressure to be carried and also permits continuous operation.

However, there is a factor, sometimes overlooked, which limits the speed to which these compressors may be slowed. This oversight, on some occasions, results in serious damage to the machine.

Many ammonia compressors depend on the splash system to lubricate the pistons, cylinders, rings, and piston rods. If the speed of the compressor is reduced too far below its intended speed, this method of lubrication becomes ineffectual and may cause these parts to be damaged.

Recently, I learned of a compressor that was slowed from 140 to 90 r.p.m. After a few hours of operation, the two pistons, rings and wrist pins ran dry and were damaged beyond repair. At the low speed crankshaft was turning too slowly to throw oil to these parts.

Of course, this speed is quite a bit lower than speeds usually encountered in ammonia compressor operation, but it serves as a concrete example of this danger. Therefore, if you intend to slow your compressor down to any extent, check the oiling system and see that it functions at the lower speed. R. F. SORRELLS.

Beaumont, Texas.

Motor Failed to Operate at Synchronous Speed

A SYNCHRONOUS motor without field will operate as a poor induction motor and takes a heavy lagging current. If operated this way very long the pole-face windings will heat and the heavy current in the stator windings will also cause serious heating. In many cases the stator current will be sufficient to trip the circuit breaker.

When putting a synchronous motor into service for the first time it was found that it would no sooner pull into synchronism than it would drop out again and take a heavy lagging current from the line which would cause the oil switch to trip out. It was also observed that the shunt exciter sometimes apparently lost its voltage when the trouble occurred.

We found that the two terminal connections on the field coils were made in such a way that they could be easily pushed together to short-circuit these coils. When the motor reached synchronous speed the centrifugal force acting on the field-coil terminals was sufficient to bring them together and short-circuit the entire group of field coils. This would cause the motor to drop out of synchronism and take a large lagging current.

Philadelphia, Pa. CHAS. A. ARMSTRONG.

Changing Two-Phase Motors for Three-Phase Operation

THE question of M. R., page 896, *Power*, June 14, relative to using a 10-hp., two-phase motor on a three-phase circuit, reminds me of experiences I had while in charge of one plant equipped with two-phase motors and

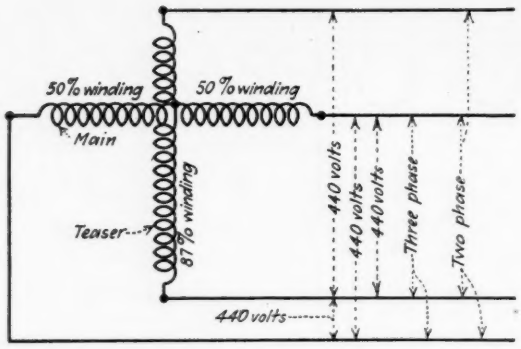


Fig. 1—Two auto-transformers grouped for both two-phase and three-phase service

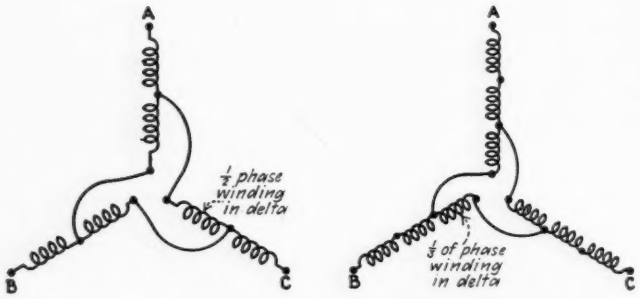


Fig. 2—Star-delta connection used on 2-, 4- or 8-pole windings. Fig. 3 (right)—Star-delta connection used on 6-pole windings

other plants that had three-phase motors installed. The interchange of motors between plants, together with the trend away from two-phase, made it necessary to standardize on three-phase equipment. To do so at the least cost and inconvenience, auto-transformers were purchased and installed on the two-phase system and connected as in Fig. 1.

The two-phase motors were left in service until necessary to make a change, when they were either rewound or reconnected, depending on which was necessary. When a winding was in poor condition it was rewound. If the motors were in good condition and required only minor repairs, they were reconnected for three-phase.

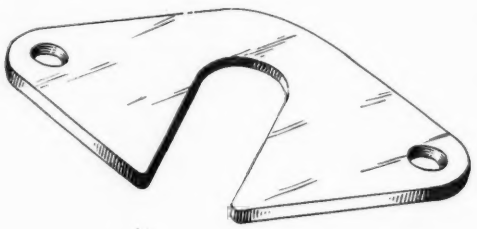
The two-phase windings were regrouped and insulated for standard three-phase operation, but instead of connecting them in star or delta, they were grouped star-delta, Figs. 2 or 3, depending on whether the motor had 2, 4, 6 or 8 poles. The rearrangement and reconnection of the stator winding utilizes all the coils of the two-phase motor and makes a balanced winding for three-phase operation. When connected as in Fig. 2 the correct voltage rating will be 97 per cent of that for two-phase, and approximately 5½ per cent higher than the two-phase rating when connected as in Fig. 3. Both values are well within the 10 per cent permissible range. The output capacity of both connections will be approximately 87 per cent of the two-phase output at the same temperature rise.

I have had a number of motors in service for several years with windings connected as in the diagrams, and they are giving satisfactory service. All of these motors are of the squirrel-cage type and there has been no indication of trouble on account of the difference in the voltage. If a motor is to be rewound the correct winding is used, but it is my opinion the usual operating conditions are such that the difference in cost between rewinding and reconnecting is sufficient to warrant reconnecting.

CHAS. R. SUGG,
Electrical Engineer,
Atlantic Coast Line Ry. Co.
Wilmington, N. C.

Emergency Gland Plate Permits Quick Repairs

ON RECIPROCATING pumps and similar equipment there is always danger that a packing gland flange may fail at a time when the equipment must be kept in service. Even if a spare gland is available, it requires considerable time to disconnct the pump, remove the old gland and put the new one in place. To allow making quick repairs I made up temporary gland plates as shown in the figure. These are made of ⅛-in. steel plate cut to the desired dimensions and drilled to suit the pump on which they are to be used. Two of these plates are used, one put in place from the top of the shaft and



the other from the bottom. I have had occasion to use these temporary flange plates at two different times. In each case it required only about 10 min. to get the pump back into service.

R. W. WILKINSON.
Philadelphia, Pa.

Wind Bulges Steel Stacks

IN GENERAL, chimneys are designed to act as vertical beams uniformly loaded on one side by the wind. The effect of the joint action of the vertical pressure due to weight and the horizontal pressure due to wind is to shift the center of pressure at the base of the chimney to one side of the axis of the shaft. The extent of this shift depends upon the magnitude of the two forces. If the center of pressure approaches too close to one side of the chimney, the stress may become zero on the windward side, allowing the joints in a masonry stack to open up. The other side, now severely overloaded, may fail by crushing. The design of such a chimney is considered safe when no such extreme shift can occur with the maximum wind.

Chimneys of brick and reinforced concrete designed in this manner have withstood winds of cyclonic proportions in the Middle West. These are so rigid in circular construction that there is no tendency to flatten due to the force of the wind.

On the other hand, unlined steel chimneys designed for stability in the same manner have given trouble in winds of much less intensity. Reasons for this have not been well understood.

A circular of the Bureau of Standards on "Wind

Pressure on Chimneys" throws light upon this problem. Tests indicate that while the velocity head due to the wind builds up a positive pressure on the windward face of the chimneys, the pressure on the leeward side varies only slightly from static pressure. On the other hand, negative pressures of considerable magnitude develop on each side of the chimney.

If the chimney is not specially designed to resist this bulging at the sides, periodic vibrations may result, with serious damage to the plant. In one large plant with chimneys superimposed on the steel frame of the boiler house, this trouble was cured only by welding on heavy girth angles at various heights.

These conditions must be carefully watched.

New York City. T. E. JARNIGAN.

Additional Starting Point Cures Control Trouble

LOCAL conditions sometimes have a marked effect upon the operation of equipment. A machine or device that operates satisfactorily under one set of conditions may develop trouble in others. This was forcibly emphasized in a number of motor controllers in one plant. The controls were of the manual reversing type with a magnetic switch to close the line circuit. The coil on this switch was connected in series with a resistor R and to a long contact B. When starting the motor, the first point was with the control handle in a position to make contact with the left-hand end of B.

A number of these controls had been installed where the operator stood near them and operated the control lever directly. Under this condition the lever was moved

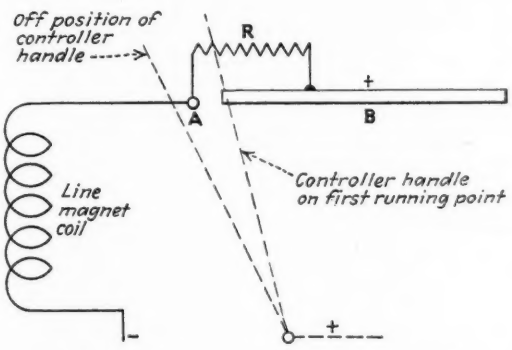


Diagram of line-switch magnet-coil circuit

to the first point in a normal manner and remained long enough on point A to allow the armature of the line magnet to seal and hold the switch closed when resistor R was connected in series with the coil. To permit the operator to start one of these motors at a position some distance away from the control an iron bar was connected to the controller lever and run to the new location. Shortly after this, the magnet coil was not closing properly, but was holding the contacts together with a light pressure that caused them to heat seriously.

The trouble was found to be caused by the operating bar binding so that when the operator applied sufficient force to move it, the control lever was moved to the first point very quickly. This did not allow contact to be made long enough with point A for the magnet switch to close with full voltage on the coil and its armature to seal, before resistance R was connected in series with the coil. The difficulty was overcome by filing a stop notch so that the control handle could be stopped readily on point A. The operator was instructed to delay the handle in this position for about one second before moving to the first running point. This simple expedient cured the trouble entirely.

Cleveland, O. M. E. WAGNER.

Chewing Gum Used to Stop Leaks

TAKE Wrigley's or similar type of chewing gum. Chew it well to remove all the soluble matter like sugar, etc. Place the gum in hot water to make it very soft, then take an equal quantity, by bulk, of Smooth-On iron cement No. 1 and work it into the soft gum. This will form a soft sticky plastic mass, which can be used as an emergency repair to leaks at corroded holes or open seams in open metal lined water tanks.

Clean around the corroded hole or open seam and dry the surface well with a cloth. Now force some of the gum and cement mixture into the hole or seam and allow it half an hour to set. Then a coating of $\frac{1}{8}$ in. or thicker of the gum mixture should be placed on top after filling the hole or open seam.

This emergency repair will stop any leak in an open cold water tank until a proper repair can be made. I have stopped a leak on the corroded bottom of an open storage tank, of $\frac{1}{4}$ in. thick iron, 6 ft. deep. Have also used it for temporary repair in tanks lined with thin copper and galvanized iron sheet.

This process will stop leaks without clamps, on illuminating or other low-pressure gas pipes. In fact, it is a cheap but mighty useful mixture to have on hand.

Parkdale, Toronto, Can. JAMES E. NOBLE.

Bending Copper Pipes

In every power plant there are always a number of small diameter copper pipes which are principally used for conveying lubricant and instrument piping. The necessity for bending such pipes is of frequent occurrence and when bending it is important that the cross-section of the pipe remain unaltered.

Before starting to bend pipe it is necessary to first anneal it by heating it to a cherry red color and allowing it to cool normally. The pipe should then be filled with molten lead, pitch, resin or sand. Where sand is used for filling previous annealing can be dispensed with, but care must be taken that afterwards every trace of sand is removed. I have found that the easiest way of bending is by means of a cylindrical piece of hardwood about two inches in diameter and 4 in. long.

In this wood are cut grooves which will take any of the variously sized pipes to be bent. This piece of wood can be held in a vise and the pipe curved around it. If the curving is done carefully, the cross-section of the pipe at the curve will not be altered.

If a dent has to be removed from a curve, the best way is to fill the pipe, tap around the dent with a wooden mallet at the same time putting pressure on the filler so that the dent is pushed out. The same method can be used to restore oval pipes to a round section.

Welwyn Garden City, Eng. W. E. WARNER.

CURRENT COMMENT

Air Heater Corrosion

THE comments of E. W. Robey of the Underfeed Stoker Co., London, England, on the subject of air heater corrosion will be of great interest to operating engineers. Mr. Robey's company, however, does not concur with certain views expressed by the writer in the March 8 number of *Power,* and in particular with the writer's advocacy of parallel flow as a means of keeping up the plate temperature of air heaters and avoiding troubles due to the condensation of the moisture and acid in the flue gases.

According to Mr. Robey, in practice the capacity of the preheater is not decreased by the recirculation of hot air. The explanation of this fact is that the decrease in the mean temperature difference between the air and gases, resulting from the increase of the entering air temperature, is offset by the increased rate of flow of air through the heater. This is not necessarily true of all air heaters, and will depend largely on how the heat transmission coefficient from air to plate varies with the mass velocity of the air. There is clearly a limit to the amount of recirculation which may be made without loss of efficiency, although in practice this limit may not be reached. Where the mean temperature difference between air and gases is small, the sooner will the efficiency fall off due to the recirculation.

It is true that the amount of recirculated air required may be minimized by arranging the air intake above the boilers, but this should always be done where possible, whether the heater is operated in counter or parallel flow. It may also be stated that the only purpose of recirculation is to keep up the plate temperature and all the benefits of this higher plate temperature are realized with parallel flow just as much as in counter flow with recirculation.

Mr. Robey states that the suggestion to use parallel flow air heaters instead of the conventional counter flow as a means of maintaining the plate temperature is quite impracticable in the majority of cases. Not only is it practicable, but it has been used by the writer with an air heater made by Mr. Robey's company. In the "Trans. A.S.M.E.," Jan., 1932, "Fuels and Steam Power," it is reported that one of the plate type air heaters at the boiler plant of Louisiana Steam Products, Inc., is worked in parallel flow with the object of keeping up the plate temperature at the gas exit end, and avoiding corrosion from gases formed in burning acid sludge. With tubular and sectional-plate type air preheaters it is quite a simple matter to arrange ducting to work the gas exit end in parallel flow and the gas inlet end in counter flow. But with some designs of air heaters built up of large single elements, it is impossible to arrange ducting so that the heater may work partly in parallel flow. Mr. Robey is correct in stating that the use of parallel flow throughout the air heater would seriously restrict the field of application.

In taking the example quoted by Mr. Robey, in which a final gas temperature of 250 deg. F. is required with a final air temperature of 200 deg. F., it will be assumed that the inlet air temperature is 60 deg. F. Assuming also that the ratio of air rise to gas drop is 1.2 to 1 then an air heater working entirely in parallel flow for this duty would be 24 per cent larger than one working in counter flow. This is a substantial increase, but not an enormous heater. If, however, the inlet gas temperature were as high as 500 deg. F., then it would be impossible, with parallel flow alone, to reduce the gases to 250 deg. F., and an air heater employing both counter and parallel flow would have to be employed.

Northwich, England. B. M. THORNTON.

Connecting Alternating-Current Generators in Parallel

THE short article "Connecting Alternating-Current Generators in Parallel" by S. Ein in the August number of *Power* raises a question about which there is considerable misunderstanding. Mr. Ein opposes the idea that to put the incoming machine in service with a minimum of disturbance it should be running slightly fast, which will be indicated by the synchroscope pointer turning very slowly in the fast direction. Nevertheless, if Mr. Ein will correctly follow this practice he will find that it will produce the minimum of disturbance in the power system when the incoming machine is connected.

First, consider what happens when the machine is running at a speed slightly below that corresponding to the frequency of the power system. If the switch is closed as the machine approaches synchronism, its speed must be slightly increased to pull it into synchronism. The only way that this can be done is by taking power from the system to accelerate the generator to synchronous speed first and then to hold it at that speed. This means that more load will be added to the machines that are supplying the load. Therefore, instead of the incoming machine relieving the loaded generators it adds to their burden until the load is adjusted between the different units by the operator.

If the machine is connected to the system when running slightly fast, it will pick up load immediately and will relieve the other machines. The time to close the switch is when the synchroscope pointer is turning very slowly in the fast direction and has approached to within about $\frac{1}{4}$ in. of the mark. This distance will vary with the type of machine and the time lag between closing the pilot switch on the switchboard and when the oil switch closes. The correct position of the pointer when the pilot switch is closed is something that must be determined by experiment, but about $\frac{1}{4}$ in. behind the mark is a good starting position. On the next trial a little longer distance may be tried. If the results are not as good as the first, a distance less than that can be checked.

After a few trials a position should be found where the pilot switch can be closed and have the incoming machine drop into synchronism and immediately begin picking up load with practically no disturbance to the power system.

Closing the switch when the machine is approaching synchronism causes the rotor's movement to help to carry it into step and tend to reduce the disturbance to the system. The switch should never be closed when the synchroscope pointer has passed synchronism. Under that condition the machine is going out of synchronism and the system must supply power not only to pull the rotor back into step, but also to overcome the rotor's inertia. This is likely to produce a very severe surge in the system. Closing the switch when the synchroscope pointer is $\frac{1}{8}$ in. ahead of the mark will cause more disturbance to the system than if the switch is closed with the pointer one inch behind the mark and moving toward it. In both cases the pointer is assumed to be turning slowly in the fast direction.

The voltage of the incoming generator should be correct before the switch is closed. It is better to have it slightly higher than below the system voltage. If the voltage is low on the incoming machine when the switch is closed the other machine will have to supply a magnetizing current to raise its voltage. This would also tend to add to the disturbance in the system. Synchronizing alternating-current generators is like most every other manual operation; it can be improved by the application of practice and a study of conditions.

Philadelphia, Pa. M. A. WILLIAMS.

Chemical Feed for Hot Lime Soda Softeners

UNDER the heading "Selecting Size of Raw Water Orifice for a Softener," in the May 10 number of *Power*, R. F. Hollis discussed the control of the chemical proportioner by an orifice in the raw water line, showing that the right size of orifice must be selected for the particular rates of flow to be handled. Mr. Hollis showed that for a 5,000-gal.-per-hour softener it is necessary to select from eight sizes of orifices for best results, these orifices ranging from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. in diameter.

The limitations of a standard orifice for the control of chemical proportioners, and the necessity of changing the size of the orifice when the load varies, has led to the development of a chemical proportioner actuated by a water meter. The water meter actuates electric switches. This avoids putting load on the meter so that the meter maintains its full accuracy of registration. When a given volume of water is passed through the meter a switch is closed, and a small motor in the control unit is started up, which lowers the swing draw-off pipe in the chemical tank a definite amount. The motor, after it has rotated a certain number of revolutions, stops automatically, then the cycle is repeated.

Mr. Hollis also recommends that the orifice which is employed in the type of feed with which he is familiar be equipped with some rate of flow element to help the operator in control of the equipment. The type of feed just described provides this element in the form of a standard water meter.

Among the advantages of this type of equipment are positive chemical feed by motor-driven units, unrestricted chemical flow (the draw-off pipe in the chemical tank drains from the surface through an unrestricted opening as the pipe is gradually lowered), possibility of separating meter and feed control widely, ease of adjustment, visible setting.

Finally, with this type of control it is possible to provide independent controls for several chemicals.

New York City S. B. APPLEABUM,
Vice-President, The Permutit Co.

Further Points On Babbitt

So A. Hoyt Levy (*Power*—July, page 35) thinks that I am a bit barmy in my views on babbitt? Lord Bacon said, "A little learning is a dangerous thing." Perhaps this applies to me as well, but there are a few points that I would like to bring out. I never knew that a magnet would fail to pick up iron or steel. This is important, if true, as Mr. Levy can construct a perpetual motion machine that will mote, if he can annihilate the force of magnetism. It is possible that he has been experimenting with a toy magnet, but if he will get a real magnet, he will find that it will pull a small particle of iron or steel at a distance of a foot, even if it is coated with tin or babbitt. Reclaimers of brass foundry scrap use nothing but a strong magnet and a shaking table, the latter to remove sand or clay.

Another point is that if he will melt his babbitt as I suggested, covered with oil, he will have no dross. Dross is not an impurity; it is an oxide or oxides of the metals present. All the metal can be converted to oxide if desired, just as litharge is made from pig lead. The argument that the dross is high in tin is natural, tin being the most prevalent metal and the most easily oxidized. Babbitt admitted that he was not sure that his formula was correct, and the point I have tried to bring out is that a variation of a few per cent either way is not a calamity.

Again, I did not say what my way of rebabbitting involved. That question was not asked. I said, "it is common practice to use remelted babbitt."

St. Louis, Mo. L. R. BAKER.

Air in Boiler Drum Causes Drop in Turbine Vacuum

IN THE Nov. 10, 1931, number of *Power*, in the discussion relative to methods of putting boilers on the line (page 687), nothing is said relative to blowing off the air which is trapped in the boiler when it is started. We agree, in general, with the methods suggested relative to handling the valves, etc., except that we allow the boiler pressure to build up high enough to operate the pop valve on the superheater header. We, thereby, blow off these gases to atmosphere and then proceed to put the boiler on the line. We find if we do not do this, these noncondensable gases which are trapped in the boiler pass over with the first steam and cause a serious drop in the vacuum on the steam turbine for a short time. Sometimes this amounts to as much as 10 to 15 in. of mercury. We are wondering whether other operators have had the same experience. RALPH EMMONS.

Kalamazoo, Mich.

READER'S PROBLEMS

PUMPING WATER RECEIVED UNDER PRESSURE—*A centrifugal pump operates with a suction lift of 5 ft. and discharges to a tank 50 ft. above its center line. If water is supplied to the intake of the pump's casing at a pressure equivalent to 70 ft. can it discharge into a tank 120 ft. above its center line?* M. E. W.

Under the original conditions the pump developed a total head equal to the suction lift plus the discharge head, or $5 + 50 = 55$ ft. The positive pressure on the intake of the pump may be added to the total head it will develop to obtain the head that can be discharged against. In the problem the total discharge head will be $55 + 70 = 125$ ft. This is 5 ft. in excess of the height of the tank above the pump's center line. Losses in the piping to the high tank will probably be greater than those to a low-rise tank. However, these should be sufficiently less than 5 ft. to insure that the pump discharges into the high-rise tank.

ALTERNATOR-EXCITER CAPACITY—*About how large should an exciter be for a given alternating-current generator?* L.W.

Exciter capacity relative to the alternator's rating will vary with the size, speed and the power factor for which the latter is designed. Exciters of a rating equal to one or two per cent of the alternator's capacity are usually provided. A higher percentage of exciter capacity is provided for small alternators that are to operate at a comparatively low lagging power factor than for large alternators designed to supply a high-power-factor load.

CAN A MAN REPAIR HIS OWN MACHINES?—*I have been told that it is unlawful for me, as engineer for the owner, to make repairs on machines in our plant, where such machines are patented. Is this correct?* J. N. H.

Here is an interpretation of the law concerning the repair of patented machinery:

Case I. The owner or his agent may legally make repairs on patented machinery provided that such repairs are confined to the unpatented parts which wear out or are broken.

That is to say, an oil still or a stoker may be built under certain patents but these patents may apply only to specific parts. Those parts which form no part of the essential invention covered by the patent can be replaced lawfully by the legal owner wherever, whenever and however he may wish and without asking the consent of the patentee. The owner may even substitute for any unpatented part of any device another unpatented part for the purpose of improving the operation of the device.

Case II. When, however, the device sold contains parts which are a definite part of a patented invention and which in the natural course of operation wear out and need replacement, such parts cannot be made by the owner or purchased from any other person than the patentee. In fact, anyone making and selling such parts is liable as a contributory infringer.

Some people have made a business of collecting worn out parts of patented devices, reconstructing them and selling them to owners. This is not lawful, and anyone doing such a business is liable for damages for infringement.

CONDUCTOR SIZES REQUIRED FOR LAMP LOAD—*What is the best method of supplying a direct-current lighting load of 420 amp. at 220 volts to a foot-ball field 1,366 ft. away from the power house? The plant is now supplying other lighting loads near the plant over feeders designed on a basis of 2 per cent voltage drop at full load.* V. A. C.

The character of the load indicates that it will be available at infrequent periods, consequently line losses are of secondary importance. It is, however, desirable to keep the line cost as low as possible. One of the solutions to the problem is to allow a 5 or a 10 per cent loss in the line and select conductors on that basis. To have this method work satisfactorily the load will have to be fairly constant near its maximum value and the lamps selected for a voltage equal to that at the power house busbars minus the voltage drop in the line. Allowing 20 volts line drop the size of the conductors required would be

$$circ.mils = \frac{21.5 \times 1{,}366 \times 420}{20} =$$

616,749 or, 600,000-circ.-mil wire may be used.

Conductors of 300,000-circ.-mil cross-section will be large enough to carry the current, but with a load of 420 amp. they will have a voltage drop of $\frac{21.5 \times 1{,}366 \times 420}{300{,}000} = 41$ volts. Conductors of this size may be used and a booster connected in series with the line at the power house. This booster should be designed to raise the voltage 41 volts when full load is on the line.

Another solution to the problem would be to supply the power from one generator in the power house and design the line to allow a drop equal to the excess voltage of the generator above a given value. For example, assume that the generator will produce 250 volts when supplying a load of 420 amp., which gives an excess of 30 volts above 220. Allowing this excess as drop in the line, 400,000-circ.mil conductors may be used to supply a standard 220-volt lamp load. With this arrangement it will be advisable to run two pilot wires from the load to a voltmeter in the power house, so that the generator's voltage may be adjusted to be correct at the load center.

VOLUMETRIC EFFICIENCY OF AN AIR COMPRESSOR—*What is the volumetric efficiency of an air compressor and what factors influence it?* A. R. R.

A compressor's capacity is expressed as the quantity of air delivered to it in cubic feet of free dry air at intake pressure and temperature. Volumetric efficiency is the ratio of the compressor's capacity per stroke in cubic inches of free dry air to its piston displacement in cubic inches. This efficiency is affected by the clearance volume, leakage of valves and piston, loss due to valve slip and increase in the air temperature as it passes into the cylinder.

If the clearance volume is 40 cu.in. and the volume swept through by the piston is 2,000 cu.in., the compressor has 2 per cent clearance. When the piston starts on its suction stroke after discharge, the air in the clearance space is at discharge pressure. Before the intake valve will open, the piston will have to travel far enough on the return stroke to reduce the pressure of the clearance air below intake pressure. For example, the piston may travel 10 per cent of the stroke before the cylinder's pressure drops to that of the intake, and air begins to flow into the cylinder. Under this condition, 10 per cent of the volume swept through by the piston is required to accommodate the air in the clearance space.

Valve and piston leakage may amount to considerable if the valves are not of good design or are not kept in good condition. Unless the surface of the cylinder's bore is in good condition and the piston fits accurately, leakage by the piston may amount to quite a percentage of the total air taken into the cylinder. Losses due to valve slip are caused by the air valve not closing tightly at the exact end of the piston's stroke, but remaining off the seat for a short time when the piston starts on the compression stroke. With good valve action this loss should be very small.

As the air comes into the cylinder some of it comes in contact with the high-temperature walls. As a result the air is heated to a higher temperature than outside and its volume is increased, which decreases the amount taken into the cylinder. The design of the water jacket and the quantity, quality and temperature of the cooling water influence the loss in volumetric efficiency because of the increased temperature of incoming air.

Oil Cooling Water Worth Recovering If Investment is Low

Readers replying to question in July issue show that problem is simple but that oil leaks must be avoided

The Question

THE water used to cool the crank-case oil in our uniflow engines amounts to about 290,000 cu.ft. per year. The make-up water required by our boilers is about 72,500 cu.ft. per year. Our CO_2 recorder requires about 21,000 cu.ft. of water per year. Water for these three purposes all comes from the same source.

We have two uniflow engines and two oil coolers. Why not pipe the discharge from these two oil coolers into a header, and pass this water to our boilers by way of our water softener and feedwater heater and pumps, taking a tap off for the CO_2 meter supply between the oil coolers and the softener?

Could we not install a thermostatic valve to release some water to the sewer in case the softener and CO_2 meter did not take enough water to cool the crank-case oil? In this case the thermostatic element could be located in the discharge from the oil cooler.

It will be noted that the water required by the CO_2 meter and boilers totals about 93,000 cu.ft. per year, which is considerably less than the water required by the oil coolers.

Might Pay to Invest Up to $400

THE proposed change in flow of water in the system, as stated in the question, is entirely feasible. There is no apparent reason why satisfactory operation could not be obtained with the plan suggested, unless there are some unfavorable conditions that are not stated in the question.

Flow of water to the sewer, which may be necessary to obtain sufficient water through the oil coolers, may be controlled satisfactorily with a valve operated by a thermostatic element in the oil line leaving the cooler. A satisfactory control of this type may be obtained from several manufacturers of meters and instruments.

Inasmuch as the proposed change is evidently an attempt to make a saving in money, it is probably fitting that some kind of cost analysis be made. Of course, the cost of water, which is unknown, is the basis of calculating the saving, but the following assumption may give some idea of the benefit obtained by the change in the system.

	Present System	Proposed System
Total water consumed, cu.ft. per year	383,000	290,000
At $2.00 per 1,000 cu.ft. for first 5,000 cu.ft.	$10.00	$10.00
At $1.00 per 1,000 cu.ft. for next 45,000 cu.ft.	45.00	45.00
At $0.75 per 1,000 cu.ft. for all over 50,000 cu.ft.	249.75	180.00
	$304.75	$235.00

Saving = $69.75 per year.

Assuming interest, depreciation, taxes, etc., as 15 per cent, the justified capital investment for the savings expected is $\frac{69.75}{0.15} = \$465$.

Another plan that should be considered is the possibility of passing the condensate from the uniflow engines through the oil coolers before returning it to the boilers. If this is possible, the present supply of water to the oil cooler would not be needed unless an emergency arose. However, the design of the present oil coolers and the quantity and temperature of the condensate must be studied in order to determine if the temperature of the oil can be controlled properly. With this scheme, a water supply other than condensate may be needed to supplement the cooling during part of the summer period. E. L. NINGARD.

Baltimore, Md.

Look Out For Oil Leaks

IN THE operation of any practical oil cooler, the pressure of the oil is always maintained at least a few pounds above the water pressure. With this practice, if any leaks develop in the cooler, the oil will leak into the water rather than the water leak into the oil. This is naturally to be desired to avoid taking a chance of having the water leak into the oil system and possibly cause a harmful emulsion.

If the water from the oil coolers were used in the boilers it would be very undesirable to have any oil enter the boilers with it. Danger of priming would especially be present.

Although the heaters used might be of the most modern type, there is always the danger of leaks developing. In case such leaks did occur, this oil would gradually accumulate in the boilers until trouble occurred. This type of leak would probably not be noticed until the damage had been done.

It is quite feasible to arrange the necessary piping and equipment so that this water can be used in the boilers and CO_2 instruments. However, great care should be exercised in watching for leaks. They can best be discovered by watching the excess water coming from the coolers for an oil film on top.

The thermostatic control could also be designed to take care of the excess water. Such controls are listed on the market by several companies.

Even with no information given as to the initial and final temperatures of the water as it goes through the coolers, etc., I would say that, with so little equipment necessary for the arrangement of the system, it would easily pay for itself from a thermodynamic point of view. The chance of oil leaking into the system seems to be the major handicap. R. F. SORRELLS.

Beaumont, Tex.

Install Small Storage Tank

IT IS feasible to use the cooling water for the boilers and CO_2 recorder. One gallon per minute is 70,000 cu.ft. per year, so the combined requirements of boilers and recorder are less than $1\frac{1}{2}$ g.p.m.

It seems to me that the simplest way would be to place a 50-gal. drum high enough so that the water required for re-use can flow by gravity, and the surplus, which is about $2\frac{3}{4}$ gal. per min., can overflow into the sewer.

If the thermostatic valve is on hand, I would use it, otherwise not, as the saving in water at St. Louis (City) prices would be only $70 a year, and the heat saved is negligible.

If the water is pumped locally, the saving would be from one-half to one-fifth of this, not enough to justify buying expensive equipment, unless the situation is as it used to be at Ajo, Ariz., where we drank beer to save the water supply. L. R. BAKER.

St. Louis, Mo.

▼

A Question For Our Readers

THERE seems to be some difference of opinion among engineers as to the advisability of insulating flange joints in steam lines. On the one hand some point out that a pair of 6-in. flanges, left bare, will waste about one ton of coal per year and that bare flanges add to the discomfort of boiler and engine rooms in the summer time. On the other is the fact that flange insulation costs much more and saves less per running foot than the regular pipe insulation. Moreover, built-on flange insulation must be destroyed whenever it is necessary to get at the joint because of leakage. I would like to get the opinion of POWER readers as to the desirability of insulating steam flanges in general, and in particular locations, also the relative advantages of fixed and removable covers. D. F.R.

Suitable answers from readers will be paid for if space permits their publication. Typewritten replies should preferably be double-spaced.

Down Go Operating Costs on Four Large Power Systems

A SYMPOSIUM on combined reliability and economy in operation of large electric systems presented at the American Institute of Electrical Engineers' summer convention gave some interesting figures on improved plant efficiency. This symposium dealt with the power systems of the Philadelphia Electric Company; the Detroit Edison Company; the Commonwealth Edison Company of Chicago; and the Edison Electric Illuminating Company of Boston.

On the Philadelphia Electric Company's system are seven major generating stations aggregating more than 900,000 kw. capacity. Six of these are steam and one is the Conowingo hydro-electric station of 252,000-kw. capacity.

Operating economies obtained have resulted in a steady reduction in the fuel consumption per kilowatt-hour. Table I shows the pounds of coal burned per kilowatt-hour in per cent of the 1926 values.

TABLE I—REDUCTION IN FUEL CONSUMPTION ON PHILADELPHIA ELECTRIC COMPANY'S SYSTEM

Year	Fuel Rate, Per Cent of 1926 Value
1926	100
1927	97
1928	99
1929	93
1930	89
1931	84

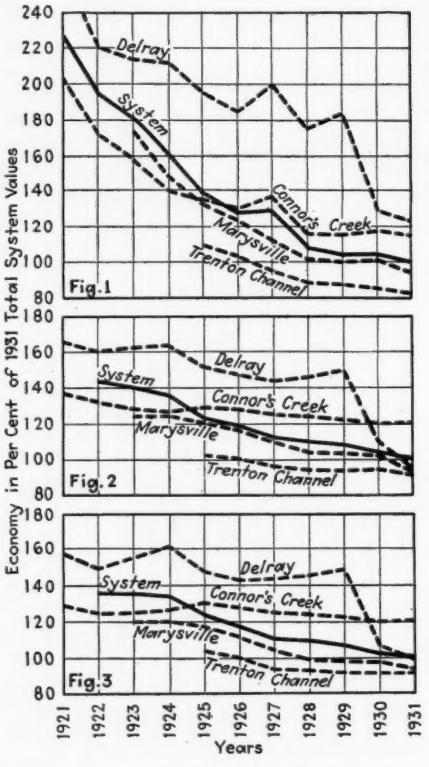
The only new and more efficient generating capacity added during the entire period was Deepwater Station, the Philadelphia Electric Company's share of which amount only to 8.4 per cent of the total system steam capacity. The increase in fuel rate per net kilowatt-hour in 1928 was caused by the initial operation of the Conowingo hydro-electric station, which necessitated running steam stations at greatly reduced load factors with abnormally large hot reserve to maintain reliability during the period of preliminary operation.

Table II gives recent data for four plants of the Detroit Edison Company's system. The active installed capacity at each plant is given in megawatts in column 2 and in per cent of total capacity in column 3. Column 4 shows the coal rate in pounds per kilowatt-hour, which varies from a low of 1.03 lb. in Trenton channel plant to 1.45 in. Connors Creek Station. The right-hand column gives the system load allocation between the different plants.

TABLE II—DATA FOR DETROIT EDISON PLANTS

Plants	Active Generator Capacity Mega-Watts	Active Generator Capacity Per Cent of Total	Coal Rate per Lb. Kw.-Hr.	Load Allocation Per Cent of System Load
Delray	110	15.3	1.12	20
Conners Creek	150	20.8	1.45	20
Marysville	160	22.1	1.07	19
Trenton Channel	300	41.6	1.03	41
Total	720			100

The curves Fig. 1 to 3 show graphically the improvement in yearly production economy for the past decade. Data are given for each of the four plants and for the system as a whole in per cent of the corresponding value for the whole system for 1931. Presented in this form, the improvement at each plant and for the system is clearly shown as well as the relative efficiencies of the different plants. Since the cost of a kilowatt-hour is the absolute criterion of success, Fig. 1 shows the production cost in that form. This figure includes cost of coal, miscellaneous supplies, maintenance, labor, office and executive personnel and such items. Since this value includes various factors over which the operator has little control, such as the varying price of supplies and labor, a better comparison of the actual improvement in thermal efficiency which can be credited to the method of plant operation is given by the pounds of coal per kilowatt-hour and the heat units per kilowatt-hour, which are shown in Figs. 2 and 3, respectively.



Figs. 1 to 3—Yearly power generation data for Detroit Edison Company plants

Fig. 1—Cost in cents per net kw.-hr.; 100 per cent = 0.334. Fig. 2—Coal rate in lb. per net kw.-hr.; 100 per cent = 1.184.

Fig. 3—Thermal efficiency in B.t.u. per kw.-hr.; 100 per cent = 15,780.

On the Edison Electric Illuminating Company's system there are two main steam generating stations with an aggregate capacity of 368,000 kw. and several small steam and hydro-electric stations. It is also tied into the New England Power Association's 110,000-volt ring around the territory served by the company. A comparison of total operating costs per kilowatt-hour covering generating stations, substations and purchased power for the years 1920 to 1930 shows that a reduction of 62.3 per cent took place.

Fig. 4 shows the improvements in economy of stations in the Chicago district for the years 1925 to 1931 inclusive. Table III gives the rating of the 550- to 650-lb. station on the system. These stations operated at an average capacity factor in 1931 of 52.2 per cent and produced the average kilowatt-hour sent out for 13,900 heat units.

TABLE III—OPERATION OF 550- 650-LB. UNITS IN CHICAGO PLANTS, 1931

Station	Millions Kw.-Hr. Sent Out	Thousands Kw. Capacity	Capacity Factor	B.t.u. per Kw.-Hr. Sent Out
Crawford Ave.	1,880.4	424	50.6	14,914
Powerton	1,173.9	204	65.5	12,679
State Line	1,009.5	200	57.5	13,446
Waukegan	535.0	153.3(A)	31.9	13,890
Michigan City	269.8	58.5(A)	52.4	14,238
	4,868.6	1,039.8	53.2	13,900

(A) Average. One unit began service during year.

The relative improvement due to advance in turbine and boiler design is shown in the case of the State Line station, Fig. 4. The turbo-generators of the one unit have an efficiency about 4.5 per cent better than that of the next previous units in the Chicago district, but the change from chain-grate stokers to pulverized-fuel equipment, together with that improvement in turbo-generator efficiency, made a total gain in efficiency of 10.4 per cent, reducing the heat units per kilowatt-hour send-out for a period of a month or longer from about 14,500 to 13,000. The 1,200-lb. No. 2 and No. 3 units on order will have a turbo-generator efficiency of about 11.5 per cent better than No. 1 unit, and the expected overall B.t.u. per kilowatt-hour will be reduced from 13,000 to 11,500 heat units.

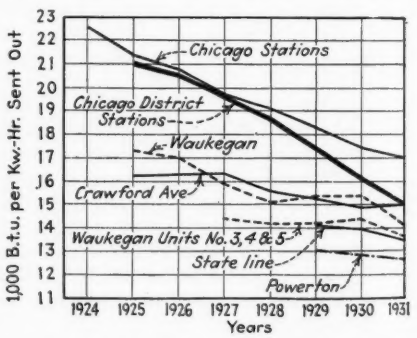


Fig. 4—Yearly average heat rate for station in the Chicago district

Constant Versus Variable Speed for Auxiliary Drives

By J. R. DARNELL

B. F. Sturtevant Company

IN THE March 29th number, pages 466-468, E. H. Throckmorton presents a novel method of calculating motor input for forced draft fans. Although substantially correct, the method of figuring variable speed brake horsepower may be simplified considerably. Also, the method used to calculate motor efficiency is, in the writer's opinion, questionable.

The author has not made it clear that *only when the system resistance curve is a parabola and the pressure varies as the square of the volume, does the volume vary directly as the fan speed.* When the pressure varies as the square of the volume, the horsepower will vary as the cube of volume or speed. Since, in the example given, the system resistance is neither a parabola nor, as given by some stoker manufacturers, a straight line, the method outlined by the author should be followed to determine the fan brake horsepower at reduced speeds.

By selecting three or more points on the system resistance curve and through each of these projecting parabolas which intersect with the static pressure curve of the fan, the author indicates that any pressure-volume point on each of these parabolas will have the same efficiency as the point at which the parabola crosses the constant speed static pressure curve of the fan. This is true enough but it is not necessary to know the static efficiency of the fan if the brake horsepower for constant speed is given.

Combining the fan-performance curves and the system resistance curve as shown in Figs. 1 and 2 respectively in the above article, curves as shown in the accompanying chart have been plotted and horsepower values determined for reduced speeds. For example, at 14,000 c.f.m. the system resistance curve shows a pressure of 3.5 in. To construct the parabola, set the runner of a slide rule over 14,000 on the *D* scale and then directly above, set 3.5 on the *B* scale. Then move the runner to the right until a point is found where the pressure readings indicated by the *B* scale and the volume readings on the *D* scale coincide with a point on the fan static-pressure curve.

By this method it is not necessary to actually construct the parabola. After a little practice, the point where the parabola crosses the pressure curve can be read from the slide rule in much less time than it takes to describe the method. For example, after setting the rule for 14,000 c.f.m. at 3.5 in., move the runner to 16,000 and read 4.58 in. Since this is below the pressure curve, move up to 16,200 at 4.7. This is found to be just slightly below, so trying 16,300 at 4.75 we find that this falls exactly on the curve. Then, reading directly down from this point to the horsepower curve, we obtain a reading of 18.0 b.hp. This means then, that if 16,300 c.f.m. is obtained at 1,750 r.p.m., requiring 18.0 b.hp., the speed necessary for 14,000 c.f.m. will be directly proportional to the volumes, and the horsepower to the cube of this speed ratio.

$\frac{14,000}{16,300} = 0.859$; then $0.859 \times 1,750 =$ 1,500 r.p.m.

$0.859^3 = 0.632$; then $0.632 \times 18.0 =$ 11.4 b.hp.

Similarly, other points on the system resistance curve are calculated and a curve for variable speed brake horsepower is then plotted.

Ordinarily, motor manufacturers do not build speed-control equipment for reduced speeds less than 50 per cent of full-load speed, but Mr. Throckmorton does not indicate at what volume half speed is reached. If the system resistance curve were a true parabola, half speed would correspond to half the full load volume and the fan would deliver 8,500 c.f.m. at 1.125 in., when running at 875 r.p.m. However, since the system resistance curve shows 2.1 in. pressure at 8,500 c.f.m., we know that the motor must run faster than 875 r.p.m. to deliver this volume. Therefore, it follows that half speed will occur at a smaller volume. To calculate the volume and pressure corresponding to half speed, it is necessary to find two volumes, the smaller being 50 per cent of the larger and the static pressure of the smaller falling on the system resistance curve while the pressure of the larger falls on the fan pressure curve for 1,750 r.p.m.

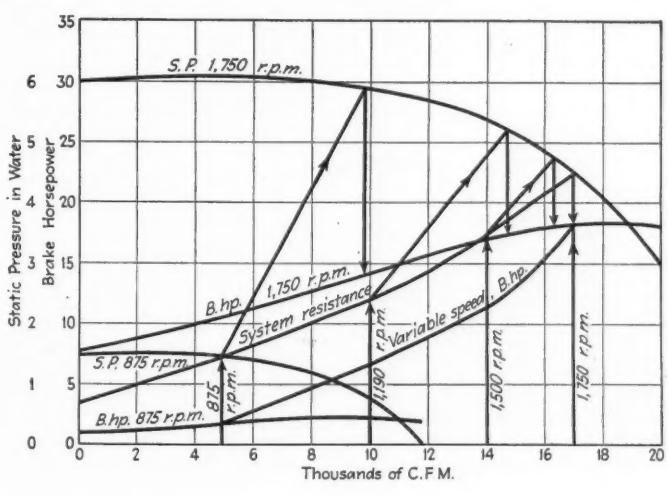
Knowing the half speed point will be less than 8,500 c.f.m., if we set the rule at 6,000 c.f.m., with a pressure of 1.65 in., a parabola through this point will cross the fan curve at 11,200 c.f.m. Since 6,000 c.f.m. is more than 50 per cent of 11,200 c.f.m., if we try 4,900 c.f.m. at 1.48 in. we will cross the fan curve at 9,800 c.f.m. Since 4,900 c.f.m. is exactly 50 per cent of 9,800 c.f.m., the fan will reach half speed at this point and the horsepower will then be 12½ per cent (0.50^3) of the value for 9,800 c.f.m.

To convert brake horsepower to motor input and then compare variable-speed with constant-speed control, it is necessary to know the motor efficiency. Mr. Throckmorton's method is to first calculate motor torque, per cent torque and then finally refer this value to Fig. 4. This method of determining motor efficiency has three questionable points:

1. What is the authority for the efficiency curve in Fig. 4?
   This applies only to motors at 1,750 r.p.m., whereas typical efficiency curves may be used for all motors at all speeds.
2. Even if correct for variable speed, it may not be for constant speed, as will be pointed out subsequently.
3. Calculation of torque, per cent of torque and then efficiency takes longer and may be subject to errors which would not occur if motor efficiency were read directly from a typical motor efficiency curve.

Referring to point 2 above, according to the author's equation for efficiency, the speed of the motor *(R)* with external resistance in the secondary circuit is compared with the speed *(R')* with no external resistance in the secondary when developing the same per cent of full-load torque as the motor with resistance in the secondary.

According to Fig. 4, at 71 per cent of full-load torque, the speed with no external resistance would be 1,765 r.p.m., but the fallacy in this reasoning is discovered when we realize, first, that with a constant-speed squirrel cage motor there is no external circuit in the secondary and no way to vary the secondary resistance, and second, that since this is so, we cannot have a speed of 1,765 r.p.m. since the author has already assumed that 1,750 r.p.m. is full load speed.



FIGURING THE CAPACITIES OF TANKS AND BOILERS

By C. R. Chadbourne

As a special service to readers who have come into the operating field without a background of technical education, "Power" presents several short articles by Mr. Chadbourne dealing with the application of elementary mathematics to power problems. These will be in a form easily followed by any man with a common-school education. Mr. Chadbourne is a member of the A.S.M.E. and of the Institution of British Engineers

SUPPOSE we have a circular tank 8 ft. in diameter and 6 ft. high. How many gallons of water will it hold? A gallon equals 231 cu.in.; we must therefore find how many cubic inches there are in the tank and divide this number by 231.

To find the number of cubic inches, we must first find the number of square inches in the bottom of the tank and multiply this by the height of the tank. The bottom is a circle. Its diameter is 8 ft.; its radius 4 ft. To find the area of a circle we square the radius, that is, multiply the radius by itself and multiply the result by 3.1416.

4 ft. equals 48 in.

```
  48
  48
 ---
 384
 192
 ---
2,304
```

The square of the radius is 2,304 sq.in.

```
  3.1416
  2304
 -------
  125664
  94248
  62832
 -------
 7,238.2464
```

There are 7,238 sq.in. in the bottom of the tank. The decimal is less than $\frac{1}{4}$ of a square inch, and is so small that it may be dropped. Multiplying the area of the bottom by the height of the tank, 72 in., we have,

```
  7,238
     72
 -------
  14,476
 50,666
 -------
521,136 cu.in.
```

Dividing by 231 to reduce to gallons we have,

```
231) 521,136( 2,256
     462
     ---
      591
      462
      ---
      1293
      1155
      ----
       1386
       1386
       ----
```

The tank holds 2,256 gal.

The same method is used in finding the capacity of a boiler. Find the area of the end of the boiler by the rule for the area of a circle and multiply this area by the length of the boiler.

For a fire-tube boiler, first find the capacity as though it had no tubes, then find the capacity of the tubes and subtract from the capacity of the boiler. To find capacity of tubes multiply the area of the end of a tube by its length and this product by the number of tubes.

Rule for Capacity of Circular Tanks or Boilers:

Capacity in gallons equals area of end in square inches, times length or height in inches, divided by 231.

Examples:

1. There is a water tank on the roof 10 ft. in diameter and 8 ft. high. How many gallons does it hold. *Answer:* 4,700 gal.

2. If the diameter were one-half as great, that is 5 ft., and the height 8 ft., would the tank hold one-half as much? *Answer:* No; it would hold one-fourth as much.

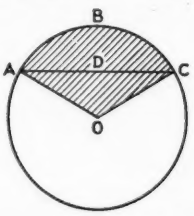
3. A boiler is 20 ft. long and 66 in. in diameter. How many gallons of water would fill it if there were no tubes? *Answer:* 3,554½ gal.

4. A water-tube boiler has 66 tubes, Each tube is 3 in. in diameter and 18 ft. long. How many cubic inches of water does each tube hold? How many gallons does the boiler hold? *Answer:* Each tube holds 1,526 cu.in. The boiler holds 436 gal.

In the preceding examples we have supposed, for the sake of simplicity, that the boiler is completely filled. That is not done in practice. To find the number of gallons actually in the boiler, we must find the contents of the space above the water and subtract this result from the entire contents of the boiler.

The contents of the space above the water may be found as follows: Let the following figure represent the end of the boiler, *AC* the water level, *O* the center of the circle. Find what fraction the arc *ABC* is of the entire circumference. The shaded area in the figure is the same fraction of the whole circle that *ABC* is of the circumference.

Example: If *ABC* were one-third of the circumference, the shaded area would be one-third of the area of the circle. But the triangle *AOC* is below the water level. We must subtract the area of the triangle from the shaded area. *DO* is the height of the water level above the center of the boiler, and *AC* the width of the boiler at the water level. Both are easily measured. One-half the length of *AC* times *DO* is the area of the triangle. Subtracting the area of the triangle from the entire shaded area gives the area of the segment above the water level. Multiplying the latter area by the length of the boiler gives the capacity to be subtracted from the entire capacity of the boiler.



Unfilled area equals segment minus triangle

5. Suppose the diameter of the boiler is 60 in., the water level is 15 in. above the center, width of boiler at water level is 52 in., length of arc *ABC* is 63 in., length of boiler 20 ft. What is the capacity in cubic inches of the space above the water?

Solution:

Area of end of boiler is 2,827 sq.in.

Circumference of boiler is 189 in., nearly.

Arc *ABC* is one-third of circumference.

Area of *AOCB* is one-third of 2,827 or 942 sq.in.

Area of triangle *AOC* is one-half of 52 × 15 or 390.

Area of segment of *ABCD* is 942 — 390 = 552 sq.in.

Length of boiler is 240 in.

552 × 240 equals 132,480 cu.in.

THE ENGINEER'S BOOKSHELF

English - German - French Dictionary

HOYER - KREUTER TECHNOLOGISCHES WÖRTERBUCH—*By A. Schlomann; 1932. 3 volumes, 2,295 pages, 7¾x11 in. Published in Germany and available through The Industrial Press, 148 Lafayette St., New York, N. Y. Price for the three volumes, $55; for two volumes, $37.50; for one volume, $19.50.*

This German-English-French technical dictionary in three volumes covers 100,000 words used in science, industry and commerce. Vol. I has German words alphabetically arranged, with definitions in English and French. Vol. II has English entry words with definitions in German and French, and Vol. III has French entry words. The series, or at least the appropriate volume, should prove of assistance to companies and individuals engaged in international trade or engineering.

Space Heating

HANDBOOK OF THE NATIONAL DISTRICT HEATING ASSOCIATION. *Published by the Association, Greenville, Ohio. Second edition, 1932. Cloth, 6x9 in., 538 pp., illustrated. Price $5.*

Much of the material contained in this book, which is published in the interests of the members of the association, results from studies and experiences of the members, although a considerable amount of general reference data is included. It is the only American book on the general subject of space heating that pays particular attention to operation as differentiated from design data. A chapter devoted to heating systems describes the proper functioning of modern systems. The last chapter in the book concerns the economical use of steam and gives data on steam consumption in various buildings. Other important chapters deal with metering, corrosion, steam distribution and miscellaneous equipment.

Refrigeration

PRINCIPLES OF REFRIGERATION. *By William H. Motz; third edition. Published by Nickerson & Collins Co., Chicago, Ill. 1932. Cloth, 6x9 in., 1019 pp., illustrated. Price $7.50, Moroco $8.50.*

Over 300 pages of new subject matter have been added in this edition, and much of the original text has been rewritten to bring the book up-to-date. Written as a text for students, it, however, contains information and data for the practicing refrigerating engineer. The book is used by the National Association Practical Refrigerating Engineers for their National Lecture Course.

The edition presents elementary and fundamental principles underlying the operation of ice making and refrigeration machinery; values of principal media used in refrigerating apparatus, fundamental laws underlying heat transfer, design, construction, erection and operation of the various parts of the refrigeration apparatus and its application to some of the more important uses.

Refrigeration Data

REFRIGERATING DATA BOOK. *Prepared and published by the American Society of Refrigerating Engineers, 37 West 39th St., New York, N. Y. Cloth, 6x9 in., 435 pages text, 127 pages catalog, illustrated. Price $3.50.*

This is the first edition of a biennial series of handbooks and is intended as a reference book. It is further indicated that the book is intended to serve as an assembly of existing factual information and as a step toward standards of various kinds, particularly of symbols, units, abbreviations and nomenclature.

Contents of the book are divided into six logical sections with headings as follows: Fundamental Data, Principles, Refrigerating Machinery, Insulation and Containers, Refrigerating Equipment, and Applications. There is also included a glossary, conversion tables, A.S.R.E. membership list and catalog section.

The wide scope of this book has made necessary a concise presentation of material and economy of space where possible. The method of indicating references to published work is an example of the extent to which space saving effort has been carried.

In addition to being of value to refrigerating engineers, this handbook also contains much data of interest to the air-conditioning engineer in chapters on psychometry, air conditioning, climatic data, insulation, piping, pumps and fans.

Evaporation and Heat Transfer

VERDUNSTUNG UND WÄRMEÜBERGANG AN SENKRECHTEN PLATTEN IN RUHENDER LUFT (EVAPORATION AND HEAT TRANSFER ON VERTICAL PLATES IN STILL AIR). *By Dr.-Ing. R. Hilpert. No. 355 of the Research Series (Supplement to "Forschung auf dem Gebiete des Ingenieurwesens" Edition B, vol. 3, July/August, 1932), Berlin, Germany; published by VDI-Verlag G.m.b.H. DIN A 4, 22 pages with illustrations and numerical tables. Paper cover, price 5 marks (VDI-members 4.50 marks).*

The tests described determine the influence of temperature on free evaporation and the influence of heat exchange by radiation to the ambient on the temperature and evaporation of the moist body. The theoretical values found by Lewis have been checked by these tests and the relation fixed between evaporation and heat transfer.

BRIEF REVIEWS

COMBUSTION OF FUELS. By Yoshik Oshima and Yoshitami Fukuda. Journal of Faculty of Engineering of Tokyo Imperial University. Vol. 20, pp. 65-99 (Feb., 1932)—Existing theories of the effect of ash on combustion of carbonaceous fuels are critically reviewed and shown to be inadequate. The evidence shows that the ash in fuel directly derived from coal (coke) retards, or at least does not accelerate combustion; while in wood fuels (chaircoal), the ash is beneficial to combustion.

QUERSCHNITTE DURCH DIE INGENIEURFORSCHUNG. By S. Erk, A. Thum, W. Lindner, M. Jakob, W. Nusselt and A. Loschge. Published by the V.D.I.-Verlag, Dorotheenstr. 40, Berlin NW. 7, Germany; 48 pages, 18 illustrations; price 3 marks.—Presenting a cross-section of engineering research, this publication contains a number of collective reports on various fields of research, with evaluations of their contents.

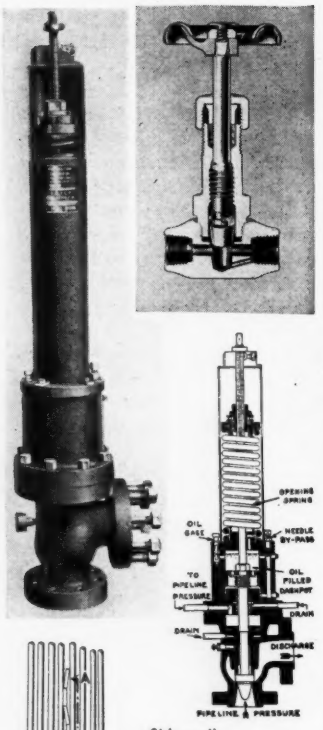
Coal Classification. By D. J. W. Kreulen, Chemisch Weekblad, Vol. 29, 367-371, June 11, 1932—A new method, based on chemical oxidation, is proposed as more precise than long accepted method of classifying coals according to their content of volatile matter. It is shown that there is a relation between the tendency to form humic acids and the ratio of fixed carbon to volatile matter.

WHAT'S NEW IN PLANT EQUIPMENT

Superheaters for H.R.T. Boilers

Superheater units of heavy-gage steel tubing, cast-steel headers, and cast-steel safety valve, all supported from main boiler shell, form "Elesco" superheater for H.R.T. boilers. Saturated-steam header (right-hand side) connected to superheated-steam header by units secured by detachable clamped joints. Safety valve nozzle extends upward at left. Steam temperature control attained by adjustment of supports regulating distance of units from boiler shell. Claimed installable without change of settings or arches.

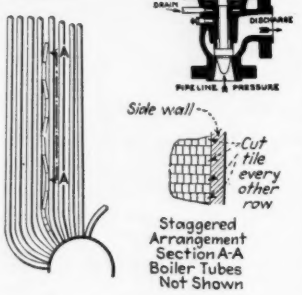
The Superheater Co., 60 East 42nd St., New York City.



Through Port Valve

Recommended for services where coking and similar troubles are encountered, these valves can be cleaned by running a rod through the line. Valve precision turned from carbon steel; stems treated for high-temperature service. Renewable slip-on disk for stainless steel is free on stem to prevent sticking and galling of seating surfaces. Non-rotatable to prevent horizontal scratching of seating surfaces. When open, disk is entirely out of passageway. Relief passage permits escape of fluids caught under plug as it closes. Body, bonnet, packing nut and gland Parkerized to protect against corrosion.

Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.



Vertical Baffle Partition

Interlocking tiles form this partition, applicable to boilers with vertical tubes. Tile sections have tongue and groove horizontal joints, lap vertical joints.

Power Plant Efficiency Co., 155 East Market St., Indianapolis, Ind.

Surge Suppressors

Essentially a relief valve for use with a check or automatically controlled gate valve, this surge suppressor is claimed to limit water-hammer disturbance positively in a pump discharge line following shutdown. Available in several forms, including Larner-Johnson and standpipe pipe for low-head development. Operating principle claimed unique in that valve opens with drop in pressure following shutdown, remaining open to relieve surge which follows, then closing automatically at an adjustable rate. Opening stroke accomplished by force of spring during low-pressure interval; valve closing adjustable by oil dashpot. During interval between opening of suppressor and return surge, check valve completes portion of its closing stroke, consequently pressure is available in line to close suppressor. Made by Pelton Water Wheel Co.

Baldwin - Southwark Corp., Southwark Division, Philadelphia, Pa.

Time Switch

Type ZYUC-10-1 Sauter 10-amp., single-pole, 2-cycle time switches are designed to close an electrical circuit automatically for predetermined time at a set period each day and a different set period each night. Have 24-hr. dials with adjustable settings, also 1-hr. dials with adjustable arms on circumference for day operation and on face for night operation. Completely automatic; require no winding. Composed of slow-speed, self-starting synchronous motor timing elements driving dials. Used for feed-water compound control, etc.

R. W. Cramer & Co., 67 Irving Place, New York City.

Lubrication System

"Metro-Matic" system has measuring valves located at points along a pipe line near bearings, each discharging predetermined amount of lubricant at each operation of pump of high-pressure, hand-plunger type. Measuring valves (illustrated) can be connected in multiple and as many branches as necessary taken off at any point. Hand pump fillable by hand or with standard Alemite equipment.

Alemite Corp., 2650 N. Crawford Ave., Chicago, Ill.

Rotary Pumps

XE series Nitralloy rotary pumps use same laminated plate construction as maker's series XA and XD. Nitralloy pumps now available with capacities from ¼ g.p.m. to 42 g.p.m. at 1,200 r.p.m., range of new series being 14 to 42 g.p.m. at 1,200 r.p.m.

Northern Pump Co., Minneapolis, Minn.

Flexible Seamless Tubing

Seamless flexible tubing offered for use where excessive flexing, slight seepage, or corrosive materials are encountered. Stocked in seamless steel and brass in sizes of $\frac{5}{32}$ to 2 in.

American Metal Hose Co., Waterbury, Conn.

Peak Limiter

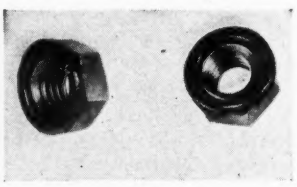
Two interconnected relays mounted in an aluminum-finished, hinged-cover knock-out box 8½ in. high, 10 in. wide, 4 in. deep, form this set. Characteristics of each relay may be varied independently to vary characteristics of device. Right-hand unit has single-pole double-throw contacts and is provided with a current-operated coil. Coil usually built in two sections, one in series with each side of a 3-wire, 220-volt line to compensate for unbalanced load conditions. Known as "Dunco."

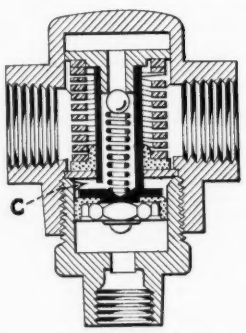
Struthers Dunn, Inc., Philadelphia, Pa.

Combination Lockwashers and Nuts

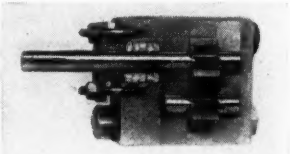
"Bracketite" combinations have lock washer fastened over a shoulder on either nut or cap-screw, thus enabling it to perform its usual function but speeding assembly.

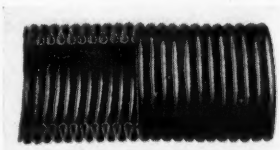
National Machine Products Co., 4850 Bellevue Ave., Detroit, Mich.





Discharging





Magnetic Clutch

This multiple-disk magnetic clutch measures only 4½ in. in diameter and requires 30 watts d.c. for operation. Torque capacity, 600 in.-lb. Unit designed for built-in drive.

Magnetic Mfg. Co., Milwaukee, Wis.

Split-Phase Motor

Types 44RB and 56RB, redesigned split-phase motors, have drip-proof endplates, wool-yarn lubrication, adjustable conduit box, and quiet, cool operation. 44RB available in 1/30 and 1/20 hp., 56RB in ⅛, ⅛, and ¼ hp., 1,725 and 1,140 r.p.m., all cycles.

Wagner Electric Corp., 6396 Plymouth Ave., St. Louis, Mo.

Single-Phase Induction Motors

Brush-riding, single-phase repulsion-start induction motors intended primarily for applications where quiet operation or higher operating characteristics are not required. Do not replace Century brush-lifting motors for long-hour-per-year applications.

Century Electric Co., St. Louis, Mo.

Improved Short-Center Drive

Rockwood short-center drives now have bases with adjustable arms for motor, and drive now adaptable to all kinds of motors for 25, 50 or 60 cycles, single or polyphase, a.c. or d.c. Adjustable arms provide means for securing correct belt tension. List of drives in stock increased to 100-hp., 1,800-r.p.m.

Rockwood Mfg. Co., 1801 English Ave., Indianapolis, Ind.

Supersensitive Relays

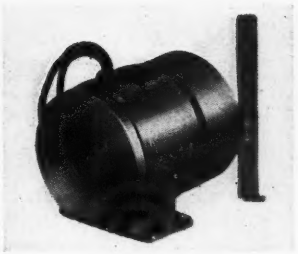
Designed to control relatively heavy currents through limited mechanical impulse from thermostat action or through variations in electrical resistance set up by varying intensity of light striking a photo-electric cell, this line of "supersensitive" relays will break 1,320 watts with 4 milliamp. at 6 volts. Relays can be provided for special purposes with coil resistances up to 50,000 ohms.

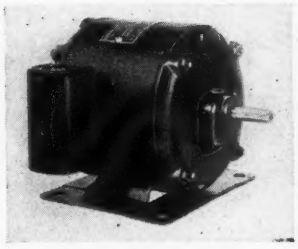
American Instrument Co., 774 Girard St., N.W., Washington, D. C.

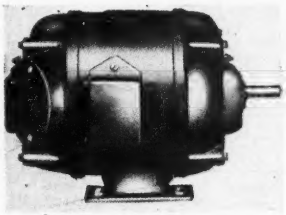
Rubber Tank or Duct Lining

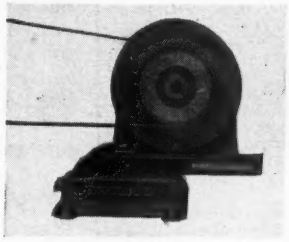
"Triflex," combined soft and hard rubber lining, has 100 times rubber's resistance to impact. Combined with brick sheathing and bonded to metal ash handling systems, etc., where high temperatures and rough service occur.

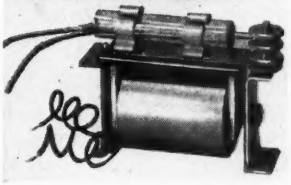
B. F. Goodrich Co., Akron, Ohio.

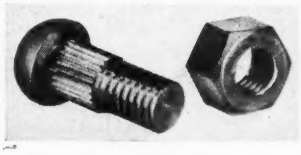








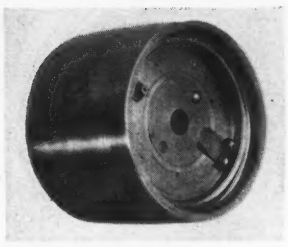


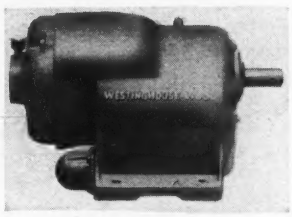


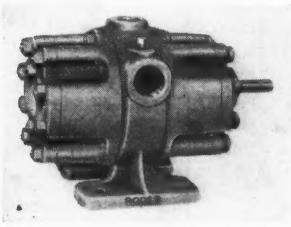
"Rivet Bolts"

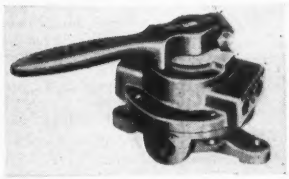
Rivet bolts have standard round heads, splined bodies about 1/32 in. larger than drilled rivet hole and shank with standard Dardelet thread to prevent backing off of nut under vibration. Bolt may be made in steel with ultimate strength of 80,000 lb. per sq.in.; higher strength steels, heat-treated, may also be used. Can be removed and reused.

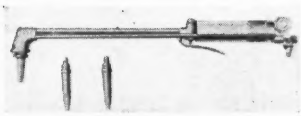
Dardelet Threadlock Corp., 120 Broadway, New York City.

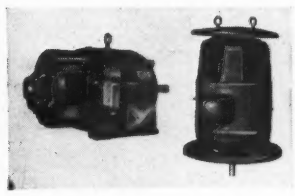












Vertical and Slip-Ring D. C. Motors

Type R d.c. motors for vertical operation ball-bearing equipped, grease lubricated and mounted on ring base or directly on driven equipment. Sizes 1-150 hp. Line of slip-ring motors extended from 20 to 250 hp., 1,800 r.p.m., 60 cycles. Complete line now ¼-250 hp.

Century Electric Co., St. Louis, Mo.

Clutch

Ramsey-Pulvis clutches can be made as part of driving member. Any capacity up to 400-hp., 200-r.p.m. can be handled. Pulvis principle incorporated consists of gradual transmission of power by centrifugal packing of hardened steel shot against driving and driven elements of clutch.

Ramsey Chain Co., Albany, N. Y.

Pressure Oiler

This portable, pressure-type spray oiler has cast aluminum body and thumb-operated trigger. Long adjustable nozzle provides one-hand oiling. Air to create pressure supplied by hand pump pressure outlet.

Techno Products Co., 7523 Santa Fe Ave., Huntington Park, Calif.

Motor-Gear Units

Westinghouse-Wood units obtained to give 900 to 60 r.p.m. on out-going shaft using 1,800-r.p.m. motor, or down to 30 r.p.m. using 900-r.p.m. motor. Slow-speed shaft can be had on one end of motor and standard-speed shaft at other. Motors furnished in polyphase, single-phase or d.c. types, ½ to 7½ hp.

H. C. Wood Machine Works, 514 Bryant St., San Francisco. Calif.

Hydraulic Pumps

Series 996 and 998 pumps will develop pressures up to 300 lb. per sq.in., Series 999 up to 100 lb. Series 996 and 998, in 9 sizes, have capacities from 4-100 g.p.m.; Series 999, in 10 sizes, from 1-100 g.p.m. Series 996 pumps have single-row ball bearings, others sleeve bearings.

Geo. D. Roper Corp., Rockford, Ill.

Duplex Air Control Valve

For use on machines employing two air cylinders operating in progressive sequence, this duplex air control valve has four independent outlet ports. Will control two double-acting cylinders in either direction. Available in two sizes, Model D-37 with ⅜-in. I. P. connections, Model D-75 with ¾-in. I. P. connections.

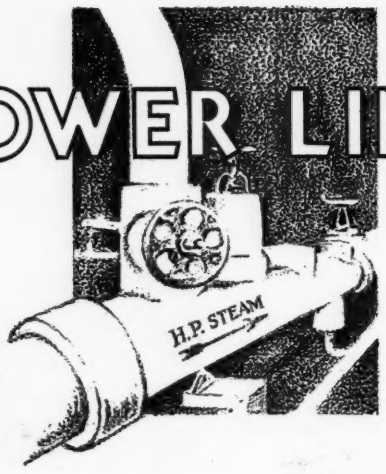
Hannifin Mfg. Co., 621 S. Kolmar Ave., Chicago, Ill.

Cutting and Welding Torch

No. 960 has been improved in design and will cut or weld normal thicknesses of metal, torch being prepared for welding by changing tip. Valves and base of forged bronze. Tubes triangularly arranged to increase strength.

Tips, Inc., 515 Cathedral St., Baltimore, Md.

POWER LINES



A.W.S. Fall Meeting To Review Welding Progress

Welding progress in many fields will be reviewed at the twelfth fall meeting of the American Welding Society to be held in Buffalo, N. Y., Oct. 3-7. Of greatest interest to power engineers will be a session devoted to welded pressure vessels.

Pressure vessel welding, particularly the welding of boiler drums and other vessels for severe-service applications, has progressed greatly under the new A.S.M.E. Welding Code. The four papers on pressure-vessel welding will cover the latest practice in this field. P. R. Hawthorne and Dr. J. C. Holmberg of Struthers Wells Company will discuss "The Application of Welding to Pressure Vessels and Metallurgy of Welds." H. L. R. Whitney of the M. W. Kellogg Company will present a paper on the welding of pressure vessels. R. S. Shepard will deal with the same subject from the angle of the oxy-acetylene process. Automatic arc welding with heavy coated electrodes, a welding technique widely used for thick-walled pressure vessels, will be discussed by L. R. Leveen of the General Electric Company.

Other papers of interest to power engineers will deal with new rolled steel design for welding fabrication, welding of high nickel alloys, use of X-rays to determine internal stresses, corrosion-fatigue testing, qualification tests of welders.

Sessions will be held at the Statler hotel and at the 174th Armory. In the latter the 14th National Metal Exposition will be staged during the entire week of Oct. 3.

The annual banquet in the Hotel Statler on Oct. 6, will be a joint affair with the American Society for Steel Treating.

Engineering Board Named to Pass on Loans by R.F.C.

A board of engineers to pass upon the engineering adequacy of projects for which applications for loans are made to the Reconstruction Finance Corporation has been named by President Hoover. It consists of six members and is headed by Charles D. Marx, professor emeritus of civil engineering at Leland Stanford University. Other members of the board are John F. Coleman, New Orleans; John Lyle Harrington, Kansas City; John H. Gregory, Baltimore; and Major General Lytle Brown, Chief of Engineers, U. S. Army, The chairman of the board was the President's own selection. The other members were selected from a list submitted by American Engineering Council.

The board was selected so that each of the major geographical divisions of the country might have representation.

COMING MEETINGS

10th National Power Show—Grand Central Palace, New York City, Dec. 5-10, during annual meeting, A.S.M.E. Conducted by International Exposition Co., Grand Central Palace, New York City. Charles F. Roth and Fred W. Payne, managers.

Safety Congress and Exhibition—21st Annual, Washington, D. C., Oct. 3-7. Headquarters of the National Safety Council, Sponsor, 20 N. Wacker Drive, Chicago, Ill.

Institution of Mechanical Engineers (Great Britain)—Summer meeting in Canada, Aug. 28-Sept. 9. Includes visits to Rochester, Schenectady and New York, including Hell Gate & Hudson Ave. power stations. Magnus Mowat, secretary, Storey's Gate, St. James Park, London, S.W.1, England.

Pennsylvania Electric Association—Annual Convention, at Bedford Springs Hotel, Bedford Springs, Pa., Sept. 7, 8 and 9.

American Society of Civil Engineers—Fall Meeting, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J., Oct. 5-8.

American Welding Society—12th Fall Meeting, Statler Hotel, Buffalo, N. Y., Oct. 3-7. Wm. Spraragan, secretary, 29 West 39th St., New York City.

American Society of Mechanical Engineers—Annual meeting, New York City, Dec. 5-9. Secretary, Calvin W. Rice, 33 West 39th St., New York.

National Association of Power Engineers—Golden Jubilee Convention, Schroeder Hotel, Milwauke, Wisc. Sept. 5-10.

Great Lakes Power Show and Mechanical Exposition—Great Lakes Power Conference, Milwaukee Auditorium, Milwaukee, Wisc. Sept. 5-10.

Association of Edison Illuminating Companies—Annual meeting, Chateau Frontenac, Quebec, Sept. 19-23.

New England Water Works Association—51st annual convention, Hotel Kimball, Springfield, Mass., Sept. 27-30. Frank J. Gifford, Secretary, Hotel Kimball.

National Safety Council—Annual Safety Congress, Wardman Park Hotel, Washington, D. C., Oct. 3-7.

National Electric Light Association—Group meeting of the Engineering Section Committees, Oct. 2-7, Edgewater Beach Hotel, Chicago.

National Council of State Boards of Engineering Examiners—Convention at New York City, Sept. 29, 30 and Oct. 1.

Consideration also was given the experience of the members along the lines that most of the applications for loans are expected to cover.

Due to the pressure on the directors of the Reconstruction Finance Corporation to pass upon an accumulation of applications under the old act, little opportunity had been given for the consideration of construction projects. The board also felt that it could not act on these projects without engineering advice, particularly as every application was inadequately supported by documents to sustain the request. With the appointment of the engineering board an immediate effort was made to classify the applications.

While the board is being handicapped greatly by the incomplete character of applications before it, it has picked out nearly 100 projects that are better supported by necessary facts than are the others and are concentrating on getting in the remaining essential information. The members are confident that the results of their work soon will begin to show.

Power Show Returns to New York

The Tenth National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York, December 5 to 10. Two years have elapsed since the last big exposition and in the interim many lines have been completely revamped and research has been responsible for many new designs and devices to meet the demands of changed economic conditions. The Exposition will offer the first opportunity to show these to engineers collectively and to explain the improvements.

Buying in the power equipment field has declined, as everybody knows. But the period through which we have been passing has provided time and opportunity for engineers and managements to survey their power facilities and plan improvements that will effect large savings in operation when production starts upward. Many such plans are already on paper awaiting the necessary appropriations as soon as available. There remains only the selection of the specific equipment.

The Exposition will assist these engineers in making their selections. Moreover, it will bring them up-to-date as to what the equipment manufacturers have been doing and afford an opportunity to make direct comparisons, unhampered by an atmosphere of intensive sales pressure.

N.A.P.E. Sponsors Great Lakes Power Conference

On Sept. 5-10 the National Association of Power Engineers celebrates at Milwaukee, Wisc., the fiftieth anniversary of its founding. At this meeting the Association can look back with pride upon its fifty years of service and accomplishment in the power engineering field.

To make this annual meeting commensurate with the occasion the N.A.P.E. has sponsored the Great Lakes Power Conference in which many engineering organizations are taking part. Among these are the American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Society of Refrigerating Engineers, American Society of Automotive Engineers, National Electric Light Association, National Marine Engineers Association, Society of Military Engineers, American Institute of Architects, Wisconsin Association of Power Engineers and the Engineering Society of Milwaukee.

The power conference will feature separate and joint meetings of the various societies, educational lectures and inspection tours as shown in the following program:

Monday, Sept. 5th.

9:00 a.m.—Registration of delegates and visitors, Milwaukee Auditorium, 5th Street Lobby.

10:30 a.m.—Opening of Great Lakes Power Conference.
G. G. Post, general chairman presiding.
Address of welcome, S. B. Way, honorary chairman.

7:30 p.m.—Opening of Great Lakes Power Show and Mechanical Exposition.

Tuesday, Sept. 6th.

9:30 a.m.—Meetings of Engineering Committees, Great Lakes Division N.E.L.A.

10:00 a.m.—Opening of Golden Jubilee Convention N.A.P.E., J. A. Prudell, presiding.
Welcome to Wisconsin, Gov. Phil LaFollette.

1:00 p.m.—First session, N.A.P.E. Convention.

2:00 p.m.—Meetings of Engineering Committees, Great Lakes Division N.E.L.A.

2:00 p.m.—Joint meeting of American Society of Heating and Ventilating Engineers and University and College group of Great Lakes Power Conference.

6.30 p.m.—Great Lakes Power Conference Banquet and Dance, Ball Room, Hotel Schroeder. $2.00 per plate.

Wednesday, Sept. 7th.

9:30 a.m.—Second session, N.A.P.E. Convention.

9:30 a.m.—Joint Meeting of Engineering Committees, Great Lakes Division N.E.L.A.

12:15—Noon—Meeting, American Institute of Architects.

1:30 p.m.—Industrial inspection and sight-seeing trips.

8:00 p.m.—Address by Maj. Gen. John Lytle Brown, U. S. Army, arranged by Engineers' Society of Milwaukee and the Society of Military Engineers, Plankinton Hall, Milwaukee Auditorium.

Thursday, Sept. 8th

9:30 a.m.—Third session, N.A.P.E. Convention.

9:30 a.m.—Meetings of Engineering Committees, Great Lakes Division, N.E.L.A.

1:30 p.m.—Sight-seeing trips.

2:00 p.m.—Fourth session, N.A.P.E. Convention.

2:00 p.m.—Meetings of Engineering Committees, Great Lakes Division N.E.L.A.

8.30 p.m.—Exibitors' Night. Minstrel Show, Plankinton Hall followed by dancing in Englemann Hall.

Friday, Sept. 9th.

9.30 a.m.—Fifth and final session, N.A.P.E. Convention.

8:30 p.m.—Installation of N.A.P.E. Officers, Hotel Schroeder Ball Room.

An additional attraction is the Great Lakes Power Show and Mechanical Exposition held at the Milwaukee Auditorium. The Schroeder Hotel has been designated as N.A.P.E. headquarters.

British Engineers Visit United States

Visiting members of the Institution of Mechanical Engineers of Great Britain, who are this year holding their annual summer meeting in Canada, left Canada on Sept. 5 for a tour of points of interest in the United States. Before arriving in New York City stops were made at Niagara Falls, Rochester and Schenectady.

In New York trips were made to the Hell Gate and East River and Hudson Avenue power plants, the Telephone Company, E. W. Bliss Company, Federal Shipbuilding and Dry Dock Company and various other points of interest.

A dinner in honor of the visting engineers is to be given by the A.S.M.E. at the Waldorf-Astoria on Sept. 9, the evening before their return to England.

Diesel Manufacturers Elect New Officers

At the recent meeting of the Diesel Engine Manufacturers' Association H. Birchard Taylor of Philadelphia was elected president, succeeding George W. Codrington of the Winton Engine Company of Cleveland, who was elected chairman of the Board. E. T. Fishwick of the Worthington Pump and Machinery Corporation continues as chairman of the executive committee.

The new president, Mr. Taylor, was graduated from the University of Pennsylvania in 1905 and entered the drafting room of the Hydraulic Department of the I. P. Morris Company, Philadelphia. In 1911 he was made hydraulic engineer.

During his career Mr. Taylor has been the president of the De La Vergne Machine Co., the Federal Steel Foundry Co., the Atlantic Coast Shipbuilders' Association (1920-21), vice-president and member of council (1924-25) of the American Society of Mechanical Engineers and is now president of the General Alumni Society of the University of Pennsylvania and consulting engineer to the Baldwin Locomotive Works

Arc Welding Patents Not Infringed

A decision of importance in the arc welding field has been handed down by Judges Alschuler, Evans and Sparks in the U. S. Circuit Court of Appeals for the Seventh Circuit, in Chicago, under date of July 29.

The case was that of the Automatic Arc Welding Company vs. A. O. Smith Corporation, involving three patents held by the appellant and numbered 1648560, November 8, 1927; 1278985, September 17, 1918 and 1648562, November 8, 1927, covering electric arc welding control methods.

The appellant sought to enjoin A. O. Smith Corporation for alleged infringement and to collect damages for past infringements. The Court decided that A. O. Smith Corporation did not infringe with its design of automatic feeding devices. The validity of the three Morton patents was not tested in the decision.

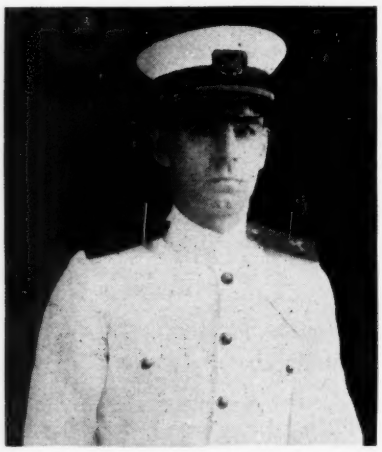
Automatic feeding devices for welding rod were reviewed and similarity with carbon electrode feeding devices in arc lamps and electric furnaces, as well as those employed in the special arc lamps used for motion picture machines, were discussed.

New York Edison Celebrates First Commercial Lighting System

September 4, 1932, marks the 50th Anniversary of Thomas A. Edison's first permanent commercial incandescent electric lighting system. This first Edison system was the Pearl St. Station and district in lower New York City. The New York Edison Company is sponsoring plans to celebrate this event on two dates, September 4 and 12. The September 4 program will be held at the site of the old station, 255-257 Pearl St. The September 12 program will be a dinner at the Waldorf-Astoria Hotel attended by representatives of civic, scientific and engineering bodies.

Power Subscriber Wins Congressional Medal

On August 18th at the Portsmouth, N. H., Navy Yard, Charles W. Willey, Warrant Machinist of U. S. Navy retired, was presented with his Congressional Medal of Honor, for heroism, which is the highest recognition that



can be given any officer or enlisted man in military or naval service. The medal with its accompanying citations was presented by an aid delegate of President Hoover in the presence of all officers and military and navy men at that station together with the public officials of Concord and Portsmouth.

The act of heroism for which the medal was awarded occurred 16 years ago when the recipient was a warrant machinist aboard the U.S.S. *Memphis* when she was wrecked in a hurricane off Santo Domingo in 1916 by being driven ashore and struck with such force that some of her steam pipes were ruptured. Mr. Willey was in the fireroom at the time and although he could have escaped without serious injury he went to the rescue of men entrapped in a steam filled section of the ship and in so doing was so badly burned that he was nearly two years in a hospital.

Mr. Willey has been a regular contributor to *Power* for many years and a subscriber since 1930.

Russel Henry Ballard Dies Suddenly

Russel Henry Ballard, President of the Southern California Edison Company, died suddenly Wednesday, Aug. 24, after a relapse from an attack of influenza suffered a month ago.

Mr. Ballard has been an outstanding figure in the electrical industry of the United States. During his thirty-four years as a Southern Californian, Mr. Ballard always has given generously of his time and energy to civic affairs.

When Mr. Ballard came to Los Angeles after seven years of work with the Thomson, Houston Electric Company of Chicago and its successor, the General Electric Company, the West

Side Lighting Company of Los Angeles was a one-year-old concern, just launched on its way to becoming the Southern California Edison Company.

From the post of bookkeeper with the young utility company, Mr. Ballard went to the office of auditor and his advance from then on was steady, progressing thus: assistant secretary, secretary, assistant general manager, general manager, vice-president and general manager, and president and general manager. He became president of the company in March, 1928, after having been vice-president and general manager since 1924.

In recognition of his services, he has been president of the Pacific Coast Electrical Association, the National Electric Light Association and a member of the Franklin Institute of Philadelphia.

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PERSONALS

PROF. W. SPANNHAKE returned from Germany on Monday, August 22, on the Steamship *Stuttgart*. He left the following day for Boston, en route to the Massachusetts Institute of Technology, where he will give his second course of lectures on hydraulics. Professor Spannhake is also carrying on some important research upon cavitation of turbine runners.

WALTER GEIST, assistant manager of the Milling Machinery Department, including the Texrope Drive Division of the Allis-Chalmers Manufacturing Co., will sail for Europe, September 9. Mr. Geist will spend three months on the Continent and the British Isles where he will study conditions and visit Allis-Chalmers Manufacturing and Sales Organizations in England, France, Germany, Italy and other countries.

E. C. BRANDT has been appointed manager of renewal parts in all Westinghouse plants.

The Falk Corporation, Milwaukee, announces the appointment of L. A. Graham and M. A. Carpenter as sales manager and sales promotion manager, respectively for all commercial products of the company. Foundry sales remain under the direction of A. Simonson, vice president.

WALTER B. GORDON for many years steam boiler inspector with the Hartford Steam Boiler Inspection & Insurance Company, has become the owner and head of Coynes State Steam Engineering School, which has been operating for the past 36 years.

F. J. WINTERER has been appointed superintendent of box production, G. A. Mitchell, box proposal engineer and C. H. Schramm, box designing engineer of the newly formed Shaw Box Crane & Hoist Company.

J. W. SPEAR has been appointed manager of the Westinghouse Company's new commercial air conditioning products department. W. C. Goodwin is in charge of the engineering and development of commercial air conditioning products. Mr. Spear has been in the employ of Westinghouse Company since 1924 and was formerly manager of machinery electrification industrial department. Mr. Goodwin was formerly manager of renewal parts in the engineering department.

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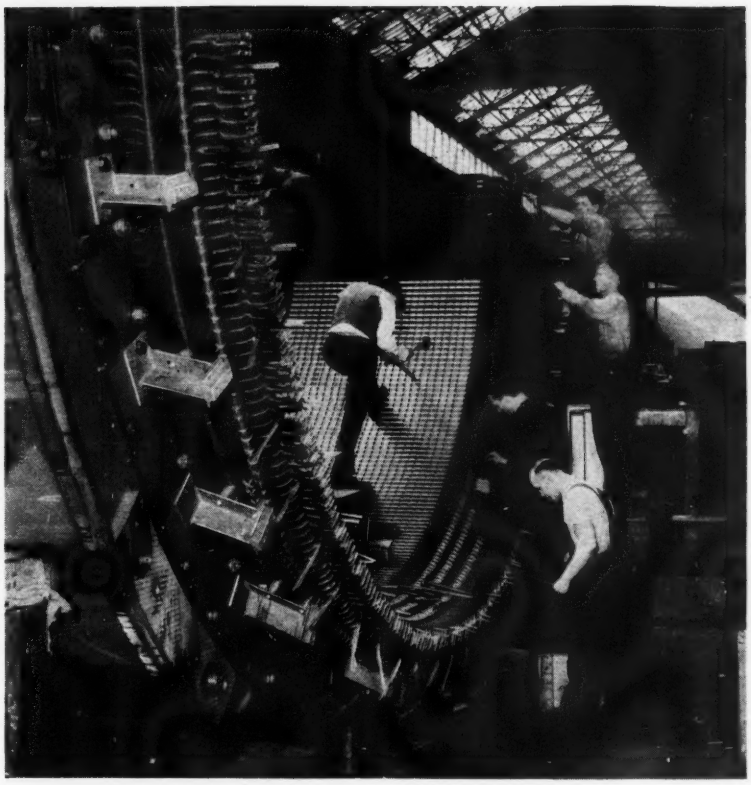
BUSINESS NOTES

The Babcock & Wilcox Tube Company announces that A. M. Tassel & Company has been appointed their distributor in the Chicago and Pacific Coast territory. The A. M. Tassel Company has warehouses in Chicago, San Francisco, Los Angeles and Seattle.

The Robbins Conveying Belt Company, 15 Park Row, New York City, has opened new sales offices in Cleveland, Detroit, St. Louis and Charleston. Robert Wisely, 229 Rockefeller Building has charge of the Cleveland Office; the Detroit office will be in charge of M. S. Lambert, 16170 La Salle Blvd.; the St. Louis office will be in charge of H. J. Martini, 7146 Dartmouth Avenue, and in Charleston, W. Va., R. U. Jackson, 905 Edgewood Avenue, will be in charge.

Manning, Maxwell & Moore, Inc., announces that it has acquired the business of the Box Crane & Hoist Corporation, Philadelphia. The plan is to merge the business thus acquired with that of the Shaw Electric Crane Company, a Manning, Maxwell & Moore subsidiary, in the Shaw plant at Muskegon, Mich. The merged business will operate as the Shaw Box Crane & Hoist Company.

The General Refractories Company, Philadelphia, Pa., announces that an arrangement has been concluded with the McLeod & Henry Company, of Troy, N. Y., whereby they are now in position to offer to the trade CARBEX (Silicon Carbide) commodities manufactured by the McLeod & Henry Company.



This huge half-hoop is part of the stator of a waterwheel generator, rated 30,000-kva., 0.85 power factor, at 150 r.p.m. Built by the Westinghouse Electric & Manufacturing Co., it is one of four units to be installed by the New Kanawha Power Company, near Charleston, West Virginia, a plant of the Union Carbide and Carbon Corp.

STRAWS

Pointing the way the business wind blows

In British Columbia the Electric Power & Gas Company, Ltd., has lodged an official application to the provincial authorities for license to divert 250 cu.ft. of water per sec. out of the Silver Hope Creek, the diverted water to be used for power purposes.

Allmon's Ltd., one of the leading manufacturers of confections, Western Canada, will erect a new concrete and brick boiler house on their property at 242 Merry St., Victoria, B. C.

Contracts were assigned for a new Department of Justice Building, at Washington, to cost $7,767,000.

The Treasury Department has let a $1,250,000 contract for steam distribution system to government buildings in Washington.

A manufacturer reports that it has stepped up 100 per cent the production of its new oil-burning furnace, and that all available welders have been recalled.

The strengthening of the bond market among the utilities enabled them to sell about $100,000,000 of bonds in July. A revival of utility buying is indicated by the $8,000,000 construction program of the Pacific Gas & Electric Company and the $8,500,000 program of the Philadelphia Electric Company.

The Potomac Power Company has awarded a contract for a $6,000,000 power house on the Anacostia River, Washington, D. C.

Mueier and Frank, a large Portland, Oregon department store, has just purchased air conditioning equipment. This is one of the largest jobs that has been closed in that territory.

The City of Denver has erected a pumping plant with a capacity of 90,000,000 gal. per day, involving a total of 3,000 hp.

Sealed proposals will be received at the U. S. Engineer Office, 1068 Navy Building, Washington, D. C., until 3 p.m., October 5, 1932, and then opened, for furnishing, installing and testing four vertical motor driven pumping units for the Booster Pumping Plant, Washington Aqueduct, Washington, D. C.

Contracts approximating $14,800 have been awarded for elevators to be installed in the U. S. Veterans Hospital at Batavia, N. Y. The contract calls for self-leveling passenger elevators having capacity of 3,500 lb. each. A small passenger elevator and a freight elevator are also included.

Eighty miles of 12-in. pipe are being laid to San Diego, Calif., to bring natural gas there. Natural gas has been authorized for seven Central Illinois towns, two in Virginia, one in Missouri, three in Iowa and one in Minnesota.

Thirty network transformers and protectors have been ordered by the Brooklyn Edison Company. The rating of each transformer is 500 kva.

The contract for furnishing, installing and operating all necessary sewage equipment for the duration of a "Century of Progress" Chicago's 1933 World Fair, has been awarded. The contract comprises four underground automatic electric pumping stations, each containing three direct-connected non-clogging vertical-shaft units varying in capacity from 1,300 to 5,700 g.p.m.

A contract for the construction of the municipal auditorium in St. Louis to cost $3,161,582 has been awarded.

The Glen Island Coal Company has awarded contracts for a new steam power plant at their Stanton Colliery. The installation totals about $350,000.

Michigan Alkali Company has stepped up production 100 per cent in their new Solid CO_2 plant (Dry Ice) at Wyandotte now producing 120 tons a day, working 24 hr. a day. It is expected that additional equipment will be installed in the fall to take care of considerable increased production scheduled for next year.

Setting an example which it is believed many other large enterprises are preparing to emulate, the United States Steel Corp. announced that an outlay of $5,000,000 has been authorized for replacements and improvements at its plants.

The American Railway Association reports an increase over the previous week in car loading of revenue freight in practically all divisions for the week ending August 13 although still considerably lower than for the corresponding weeks of 1930 and 1931.

The total car loading for the week ending August 13 totaled 512,431. This was an increase of 16,398 cars above the previous week but a reduction of 231,195 cars under the same week in 1931.

Increases were reported in the loading of miscellaneous freight, merchandise, grain and grain products. Coal loading showed an increase of 1,356 cars above the preceding week. Others showing increases were forest products, ore and coke loading and loading of live stock.

New Bulletins

INCLOSED FAN-COOLED INDUCTION MOTORS—Reliance Electric & Engineering Co., Ivanhoe Rd., Cleveland, Ohio, has issued Bulletin 112 on fully-inclosed fan-cooled "Reliance" induction motors, Type AA, Form F, including specifications, photographs, design diagrams and information.

COMBINATION TAPE—B. F. Goodrich Co., Akron, Ohio, has issued a pamphlet on its combination rubber tape and friction tapes, made of fabric imbedded in a rubber compound with a high degree of adhesion, permitting electrical joints to be wrapped in one operation.

AMMONIA GAS SEPARATORS—Hill Mfg. Co., 844 Rush St., Chicago, Ill., has issued a bulletin "Reduce Your Operating Costs," describing the Hill improved float-type noncondensable gas separator for ammonia refrigerating systems.

CORKBOARD—United Cork Co's., Lyndhurst, N, J., has issued a bulletin on "United's Corkboard," describing the insulation manufactured by the companies.

BAR STOCK VALVES—Reading-Pratt & Cady Co., Inc., Bridgeport, Conn., has issued an 8-page catalog describing its bar stock valves, made in globe, angle and cross patterns of bronze, carbon steel and stainless steel. Also described are the "Thru-Port" valve and a "Roto-Control" valve for range oil burners.

ELECTRIC PLANT—Kohler Co., Kohler, Wis., has issued a folder, "Kohler Electric Plants," which describes a number of the 73 models manufactured by the company, and shows units from 800-watt to 20-kw. capacity.

MAGNETIC CLUTCHES — Dings Magnetic Separator Co., Milwaukee, has issued a 16-page bulletin on installation and use of magnetic clutches for special and general power transmission applications. The bulletin describes three types of Dings clutches, single-disk, multiple-disk, and serrated-disk. Installation diagrams are reproduced, and the method of calculating the required horsepower rating is discussed.

EXPANSION JOINTS—Croll-Reynolds Engineering Co., Inc., 17 John St., New York, N. Y., has issued an 8-page bulletin on "FlexoDisc" expansion joints which describes these joints claimed suitable for handling expansion in a variety of piping systems and for special expansion problems, and available in sizes from 3 to 30 in.

VARIABLE-SPEED TRANSMISSION—Lewellen Mfg. Co., Columbus, Ind., has issued a bulletin on Lewellen Series 100 inclosed transmissions, listing dimensions and sizes and including design data.

FEEDWATER REGULATORS — Northern Equipment Co., Erie, Pa., has issued two folders on Copes equipment. Folder No. 127 on the new Copes Type DA Feedwater Regulator, and Folder No. 129 on the Type SDS-2 Governor.

STAINLESS STEEL MOTOR—Lincoln Electric Co., Cleveland, Ohio, has issued a bulletin, "The Stainless Steel Motor," describing in detail this motor recently described in *Power*.

VALVE COMPARISON CHART—Ohio Injector Co., Wadsworth, Ohio, has issued a complete valve comparison chart showing the company's "O.I.C." figure numbers compared with those of other valve manufacturers for various types of valves.

MIDGET VOLTMETERS & AMMETERS—Sullivan Machinery Co., 400 N. Mighigan Ave., Chicago, has issued a new loose-leaf catalog of its equipment, parts and supplies, which include a description of "Migit" portable voltmeters and ammeters.

BOILER BLOW-OFF VALVES — Cochrane Corp., North Philadelphia, Pa., has issued Bulletin 693 describing a new low-price combination or tandem blow-off valve in nickel-chromium cast iron for pressures up to 250 lb., and with cast steel for pressures up to 400 lb.

RELAYS—General Electric Co., Schenectady, N. Y., has issued a bulletin, "Relays Step Forward," under No. GEA-1583, describing the various types of relays manufactured by the company.

GAS - ENGINE - DRIVEN COMPRESSORS — Ingersoll-Rand Co., 11 Broadway, New York, N. Y., has issued a bulletin on the new Type XOG Gas-Engine-Driven Compressors.

New Plant Construction

Mc-Graw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Calif., Los Banos—Bids Sept. 7, by V. G. Bryant, city clk., altering and constructing additions in present municipal water filter plant, incl. 2 concrete rapid sand filters (alternate-substitute pressure filters for rapid sand filters), furnishing, installing 2 axial flow type pumps, complete with motors, etc. W. E. Bedesen, Shaffer Bldg., Merced engr.

Conn., Westport—Connecticut Light & Power Co., 107 West Main St., Waterbury, plans brick, concrete power sub-station, incl. equipment. Est. exceeds $25,000. Private plans.

Fla., Fort Lauderdale—Port Authority, W. T. Eller, secy., plans combined pre-cooling, cold storage and bonded warehouse. Application for loan to Reconstruction Finance Comn.

Fla., Miami — City Comn., R. B. Gautier, mayor, plans extending water service, incl. new equipment, diesel engines, etc. $500,000. Application for loan made to Reconstruction Finance Comn.

Ill., Kewanee—Election Oct. 4, to vote on installing electric power plant.

Ind., Brookville—Bids Sept. 16, by School Comrs., remodeling heating plant, incl. heating boiler, pipe covering, radiation, vacuum pump, $25,000. Harrison & Turnock, 1001 Architects & Builders Bldg., Indianapolis, archts.

Ind., Hammond—City Council plans municipal electric light and power plant. Exceeds $25,000.

Ind., Red Key—City Council, plans municipal light plant. $25,000. Private plans.

Louisiana—Bids Sept. 7, by U. S. Eng., 1st New Orleans Dist., New Orleans, constructing Vermilion Lock in Intracoastal Waterway including power house, etc. Vermilion Parish.

Me., Portland—Colonial Beacon Oil Co., 30 Beacham St., Everett, Mass., soon takes bids 1 story, basement, irregular sized, brick, concrete warehouse, garage and office building, incl. boiler room and pump room in basement. Est. exceeds $40,000. Private plans.

Mass., Boston—Yards & Docks, Wash., D. C., improving power plant, Boston Navy Yard. $100,000.

Minn., Staples—City, B. C. Barrett, clk., bids about Sept. 9, sewage disposal plant additions, comprising pump house, pumping equipment, trickling filter, resetting beds, etc. $20,000.

Neb., Ralston—City soon takes bids 40 x 60 ft. municipal light and power plant, distribution system, two 360 hp. Diesel engines with generators, exciters, switchboard, etc., $85,000-$90,000. C. V. Barnhill, 420 Federal Trust Bldg., Lincoln, engr.

N. H., Portsmouth—Bu. Yards & Docks, Navy Dpt., Wash., D. C., plans improving power plant at Navy Yard. $250,000.

N. J., Kenvil—Hercules Powder Co., Delaware Trust Bldg., Wilmington, Del., plans additional power housing facilities, installing two 500 hp. steam boilers with auxiliary equipment, and turbine for high pressure steam. $135,000.

N. J., New Brunswick—Bd. Comrs., City Hall, preliminary plans 2 compartment sedimentation basin, mixing tanks, chemical dry feed machines, 4,000,000 gal. per day raw water booster pump, filter units, revamping present filter plant, and laboratory equipment, $300,000. A. Atkinson, city engr.

N. D., Fargo—City, improving waterworks, incl. c.i. mains, hydrants, tank $46,500, filter beds, water softeners $33,500, new pumps $19,500, water meters $1,500. C. O. Jorgenson, city aud.

O., Piqua—Bids Sept. 7 by City Clerk, 1 story, steel, rein.-con. power plant building, $55,000. Burns & McDonnell, Engr. Co., 400 Interstate Bldg., Kansas City, Mo., engrs.

Pa., Erie—Comrs. Lawrence Park Twp., appointed committee c/o J. J. Casby, Lawrence Park, to secure date for proposed brick, steel, electric power plant, Lawrence Park, near here. Engineer not appointed.

Pa., Leechburg—Leechburg Water Co., additional pumping facilities and impounding reservoirs about 3 mi. from present source of supply.

Pa., Oil City—Wolverine-Empire Refining Co., Reno, A. W. Scott, secy., taking bid, improvements incl. addition to boiler house, installation of new 500 hp. boiler and complete stoking equipment, and new fuel conveyor system for plant. $30,000.

Pa., Pittsburgh—City, soon takes bids steam lines, 1,500 ft. 3 in. live steam with 4 in. return pipe, laid in concrete, from Carnegie Institute boiler plant, to Phipps Conservatory, Schenley Park. $22,000. C. M. Reppert, Pittsburgh, engr.

Pa., Pittsburgh—Carnegie Institute, R. B. Ambrose, supt., Schenley Park, extensions and replacements to boiler plant.

Tex., Dallas—Con. Q. M. plans water pumping plant at Henley Field. $5,000.

Tex., Harlingen—Cameron Co. Water Control & Impvt. Dis. 19. Voted bonds Aug. 19, irrigating 9,000 acre Adams Tract, incl. building canals, pumping unit, etc. Address District, A. Tanun, 209½ East Jackson St., engr.

Tex., Goose Creek—Municipal Utilities Inv. Co., Houston and 203 Mutual Bk. Bldg., Kansas City, Mo., plans 1 story light and power plant. $300,000. Private plans. B. J. Smith, Goose Creek, city engr.

Tex., Kerrville—City, c/o R. B. Ellis, mgr., plans light and power plant.

Va., Radford—City Council, repairing portion hydro-electric plant dam, washed out some years ago, in order to resume production power. Will make application for loan of $85,000 to Reconstruction Finance Corp. for same.

Wis., Oshkosh—City takes bids in September intercepting sewers and pumping station. $200,000. Pearse, Greeley & Hansen, 6 North Michigan Ave., Chicago, Ill., engrs.

B. C., Victoria—Ormond's Ltd., 326 West Cordova St., concrete, brick boiler house, 242 Mary St.

Ont., Hamilton—City, soon takes bids 50 ft. high, 52 x 70 ft. steel, brick, concrete power and heating plant for new maternity hospital, Mountain. $50,000. W. P. Witton, 63 John St., S. archt.

Ont., Hamilton—Hamilton Hydro-Electric System, 12 King St., E., plans by W. J. Walsh, Terminal Bldg., 1 story, brick, stone, concrete, steel, electrical substation, Central and Kenilworth Aves. $40,000. E. I. Sifton, c/o owners, engr.

Ont., Hamilton—J. Peebles, mayor, City Hall, soon lets contract 2 story, 52 x 70 ft., rein.-con., brick power house for Mountain General Hospital, $30,000. W. P. Witton, 63 John St. S., archt.

Equipment Wanted

PUMPS—**Hanford, Calif.**—City plans to install two electric pumps to replace present steam pumping equipment at pumping plant.

PUMPS—**Santa Maria, Calif.**—Santa Maria Cemetery Dist., A. Fulger, secy., will purchase one deep well pump, one booster pump and construct pump house.

TURBINE—**San Francisco, Calif.**—Con. Q. M. Fort Mason, plans 100 kw. generator set and 200 kw. turbine for generator.

TRANSFORMER PLANT EQUIPMENT — **Waterbury, Conn.**—Connecticut Light & Power Co., 107 West Main St., 1 story, brick, steel, 30 x 50 ft., brick, steel, transformer building and installing equipment. Owner builds. $25,000. Private plans.

PUMPS—**Pensacola, Fla.**—City Manager taking bids replacing present steam driven pumps with 2 electrically driven multi stage centrifugal water pumps 1,100 9 g.p.m. capacity. $12,000. O. J. Semmes, Jr., Pensacola, city engr.

PUMP—**Union Mo.**—City soon takes bids 60,000 gal. steel tank on 50 ft. tower and one 100 gal. p.m. motor-driven booster pump. $5,000. G. H. Vossbrink, city engr.

PUMPS — **Albuquerque, N. M.**—City plans drilling 2 deep wells, pipe and electrically driven pumps. Option on 2 additional wells at bid price. $25,000. C. E. Wells, asst. city engr.

ENGINE—**Grafton, N. D.**—City rejected bids furnishing, installing power plant unit, incl. 600 hp. engine. $25,000. Will readvertise.

PUMPS—**Coco Solo, C. Z.**—Bids Sept. 21, by Yards & Docks, Navy Dpt., Wash., D. C. steel tanks, ethylizing plant enclosure, motor operated pumps and fan, piping and ethylizing systems at Naval Fleet Air Base, Spec. 6620.